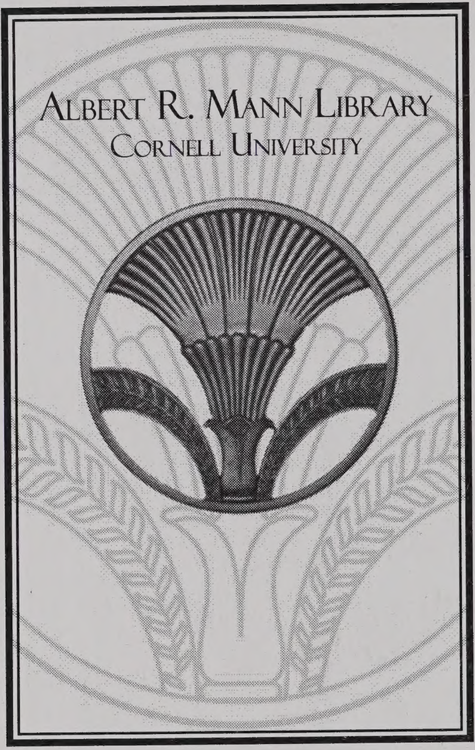

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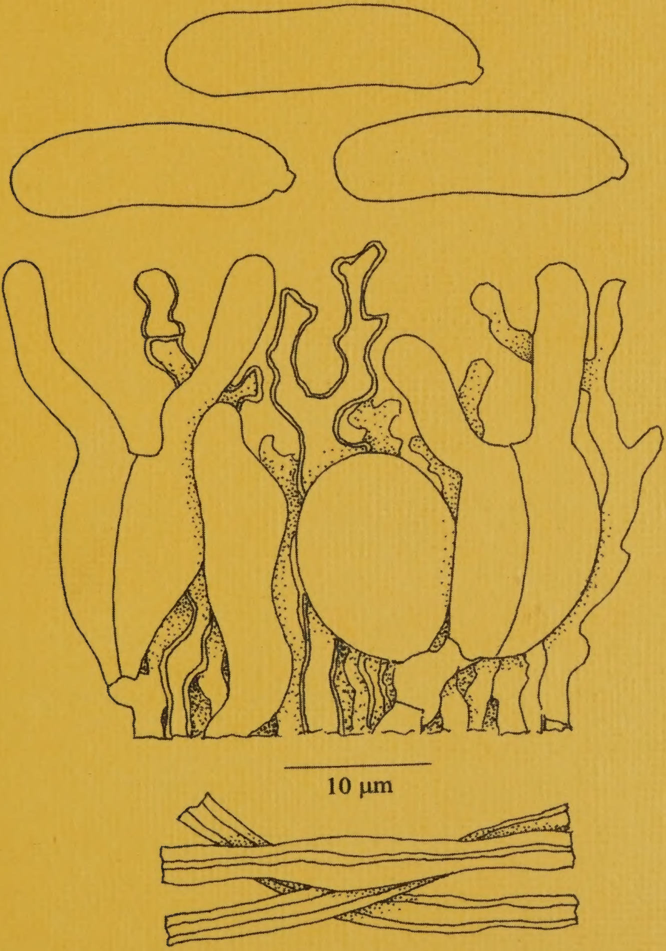

Peter Roberts
Heterochaete tenuicula
sp. nov. (p. 144, Fig 4.)

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A new *Pseudocercospora* species on *Passiflora setacea*

Alexei C. Dianese[1], Ana M. Costa[1] & José C. Dianese[2*]

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Abstract — A new *Pseudocercospora* species, *P. passiflorae-setaceae*, was detected causing severe leaf spotting on *Passiflora setacea* in Brasília, Distrito Federal, Brazil. The new species is described, and differences from other *Pseudocercospora* species on *Passiflora* are discussed.

Key words — cercosporoid fungi, *Mycosphaerellaceae*, tropical fruits, wild passion-fruit

Introduction

Native *Passiflora* L. species are common in the Cerrado as well as in other Brazilian Biomes (Cervi 1997, Nunes & Queiroz 2001, Vieira & Carneiro 2004). Among them *P. setacea* DC. deserves attention being now domesticated for fruit production. Mendes et al. (1999) listed fungal species associated with *Passiflora* in Brazil, but among them species of *Pseudocercospora* Speg. were not mentioned. Crous & Braun (2003) revised the names of hyphomycetes previously referred to as *Cercospora* Fresen. and *Passalora* Fr. and published numerous new combinations with updated descriptions of known cercosporoid fungi including those on *Passiflora* species [viz., two *Passalora* species (*Passalora biformis* (Peck) U. Braun & Crous and *P. fuscovirens* (Sacc.) U. Braun & Crous), four *Cercospora* species (*C. granadillae* Chupp, and three belonging to *C. apii* Fresen. s. lat. (viz., *C. passifloricola* Chupp, *C. regalis* Tharp, *C. truncatella* G.F. Atk.), and three *Pseudocercospora* species (*P. calospilea* (Syd.) Deighton, *P. passiflorae* U. Braun & Crous, and *P. stahlii* (F. Stevens) Deighton)] (Chupp 1954, Deighton 1976, Ellis 1976, Crous & Braun 2003). However, the fungus on *P. setacea* is quite distinct from the *Cercospora* and *Passalora* species mentioned, which possess conidiogenous cells and conidia conspicuously cicatrized. Furthermore, the new species does not coincide with the known *Pseudocercospora* species occurring on hosts of the *Passifloraceae* (Chupp 1954, Deighton 1976, Braun et al. 1999, Crous & Braun 2003, Farr et al. 2008). The specimen studied revealed unique features sufficient to be described as a new *Pseudocercospora* species.

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Materials and methods

Leaves of *P. setacea* showing strong yellow leaf spotting were collected from a passion-fruit nursery at Embrapa Cerrados in Brasília. The sample was dried, numbered and deposited in the Mycological Collection of the Herbarium of the University of Brasília (UB- Col. Micol.). Studies under the stereomicroscope were followed by observations of squash preparations and sections made with a freezing microtome. The morphological features were described, measured, and documented using a Leica DM 2500 microscope coupled with a Leica DFC 490 digital camera connected to a microcomputer. Image capture, editing, and measurements were made with the help of Leica QWin V3 software. In some cases, the samples were stained with lacto-glycerol cotton blue and the slides sealed with nail polish, but most of the photographic work was done without staining using Nomarski optics. A minimum of fifty replicates of spore and hyphal measurements were made.

Taxonomy

Pseudocercospora passiflorae-setaceae A.C. Dianese, A.M. Costa & Dianese, **sp. nov.** Figs. 1-11.

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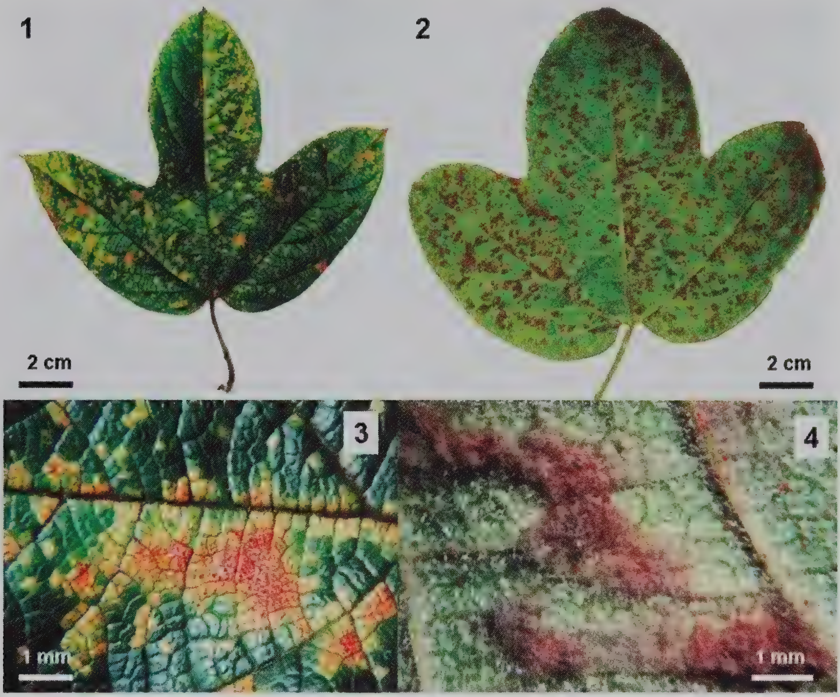
> Pseudocercosporae passiflorae *similis, sed stromatibus majoribus, (49–) 60–166 (–195) µm diam., hyphis superficialibus cum conidiophoris solitariis evolutis et conidiis longioribus et latioribus, ad 129 x 5.5 µm, ad 15-septatis.*

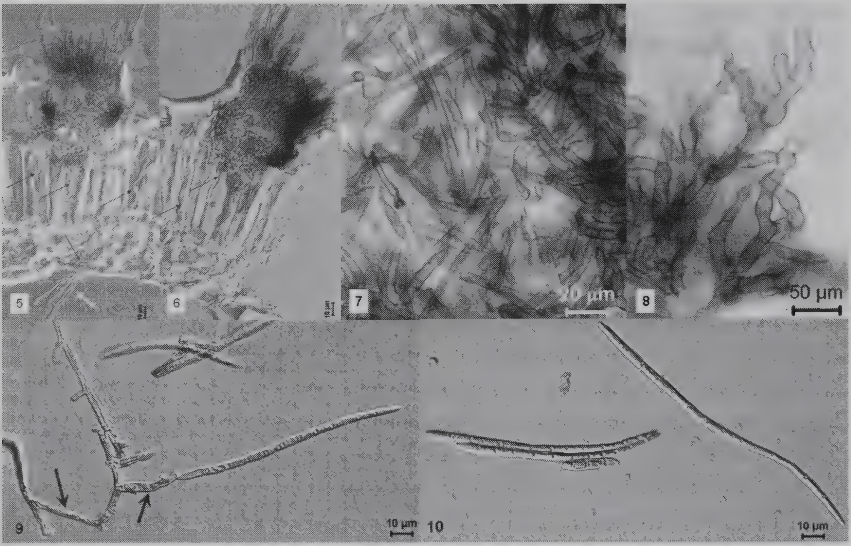
Lesions adaxial, widespread, formed as irregularly scattered yellow solitary leaf spots, later coalescing into light brown necrotic areas with central black dots; grayish irregular downy spots on the abaxial surface. Immersed mycelium septate, light brown, within the mesophyll, forming epiphyllous stromata and hypophyllous superficial mycelium. Stromata (49–)60–(102)–165(–195) µm diam, epiphyllous, subglobose to globose, brown to dark brown, subepidermal, erumpent, textura angularis. Superficial mycelium exclusively hypophyllous, strongly branched, intricate, abundant, light grayish brown to brown, giving rise to conidiophores and conidiogenous cells; hyphae 4–6 µm diam, subhyaline to light bown, septate, smooth, thin-walled. Epiphyllous conidiophores 7–(14)–21(–31) x 2.5–(4)–5 µm, numerous, densely fasciculate,



Figs. 1-4. *Pseudocercospora passiflorae-setaceae* on leaves of *Passiflora setacea*. 1. Yellow irregular leaf spots on the adaxial face. 2. Gray irregular leaf spots on the abaxial face. 3. Adaxial lesion showing small dots (stromata) in the central portion of the adaxial side. 4. Abaxial lesions covered by velvety gray superficial mycelium.

formed on stromata, geniculate, light brown, septate, smooth, Hypophyllous conidiophores solitary, arising from superficial hyphae, lateral or terminal, aseptate, i.e. conidiophores reduced to conidiogenous cells. Conidiogenous cells integrated, terminal, 20–50 µm long, sympodial; conidiogenous loci flattened, inconspicuous. Conidia solitary, cylindrical, rarely obclavate-cylindrical, 43–(86)–129 x 3–(3.5)–5.5 µm, 5–15-septate, solitary, sub-hyaline to light brown, thin-walled, smooth; apex subacute to subobtuse; base truncate to somewhat obconically truncate, 3–4.5 µm wide; hila neither thickened nor darkened.

Specimen Examined. **BRAZIL.** Distrito Federal: **Planaltina.** Centro de Pesquisa Agropecuária do Cerrado (CPAC), Km 18, Br-20 Highway North, on living leaves of *Passiflora setacea*, 12 Feb 2008, *leg. Alexei de Campos Dianese* 95, **holotype**. (UB- Col. Micol. 20872).



Figs. 5-6. *Pseudocercospora passiflorae-setaceae* on leaves of *Passiflora setacea.* Cross section of stromata with conidiophores on infected leaves showing the trans-mesophyllic mycelium (black arrows), and also the emerging hypophyllous superficial mycelium (white arrow).

Figs. 7-10. *Pseudocercospora passiflorae-setaceae.* 7. Hypophyllous intricate superficial mycelium. 8. Branching of the superficial mycelium with terminal conidiogenous cells. 9. Superficial mycelium (left arrow) bearing a geniculate conidiophore (right arrow) with a 10-septate conidium. 10. Conidia.

Discussion

All three known *Pseudocercospora* species on *Passiflora* are easily segregated from the new species, first of all, because they all lack an external hypophyllous mycelium with solitary conidiophores. Due to well-developed epiphyllous stromata with fasciculate conidiophores and similar conidia, *Pseudocercospora passiflorae* resembles *P. passiflorae-setaceae*, but the stromata are much smaller, and the conidia are shorter and narrower, usually 30–80 x 2–4 µm, only with up to 10 septa (Crous & Braun 2003). The second species on *Passiflora*, *Pseudocercospora stahlii*, was originally described from Puerto Rico as *Helminthosporium stahlii* F. Stevens in 1917, and later found in the Virgin Islands and Dominican Republic. This species is also known from 16 countries in Asia and Australia mainly affecting *Passiflora foetida* (Hsieh & Goh 1990, Hyde & Alcorn 1993, Liu 1977, Guo t al. 1998, Shaw 1984, Thaung 1984, Zhuang 2001). *Pseudocercospora stahlii* differs from *P. passiflorae-setaceae* by having amphigenous fasciculate conidiophores, smaller stromata (20–40 µm), and short, broad conidia with up to seven septa (Deighton 1976). Finally, *P. calospilea* is clearly different from the new species by its smaller hypophyllous stromata (25–35 µm diam.), hyaline to subhyaline, cylindrical-obclavate, 1-7-septate, smaller conidia (20–60 x 2–4 µm). Based on the clear morphological differences, the introduction of a new species for the *Pseudocercospora* on *Passiflora setacea* is justified.

Acknowledgements

The authors thank Embrapa, CNPq and Fundação Banco do Brasil for financial support, and Prof. Mariza Sanchez for assistance with the herbarium work, and C.A. Inácio for help with the photographic work. Also sincere thanks are given to Drs. Uwe Braun and Roland Kirschner for the pre-submission reviews of our manuscript.

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Type studies on South American *Strophariaceae*: 2. *Pholiota trinitensis* is transferred to *Stropharia*

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Abstract — The holotype of *Pholiota trinitensis* (= *Hypholoma trinitensis*) was examined, and the presence of numerous acanthocytes in its rhizomorphs necessitates its transfer to the genus *Stropharia.* The new combination, *S. trinitensis,* is proposed. The taxonomic discussion is accompanied by a brief description and illustrations of relevant microscopic features.

Key words — *Agaricales, Naematoloma,* neotropical mycobiota, nomenclature

This new contribution to type studies on South American *Strophariaceae* Singer & A.H. Sm. (Cortez 2008) presents results from the type study of *Pholiota trinitensis.* Although originally described from Central America (Trinidad Isl.), there are known records for the species from Brazil (Pegler 1997 from São Paulo State; de Meijer 2006 from Paraná State; Bononi et al. 2007 from Mato Grosso do Sul State) and Argentina (Lechner et al. 2006). This species was described initially in *Pholiota* (Fr.) P. Kumm., later transferred to *Hypholoma* (Fr.) P. Kumm. (Pegler 1983), and then to *Naematoloma* P. Karst. (Singer 1986). However, the characters listed by Dennis and Pegler suggest that the species belongs to *Stropharia* (Fr.) Quél. following the current concept proposed by Cortez & Silveira (2008). The author therefore considered it necessary to examine the holotype to clarify its generic position.

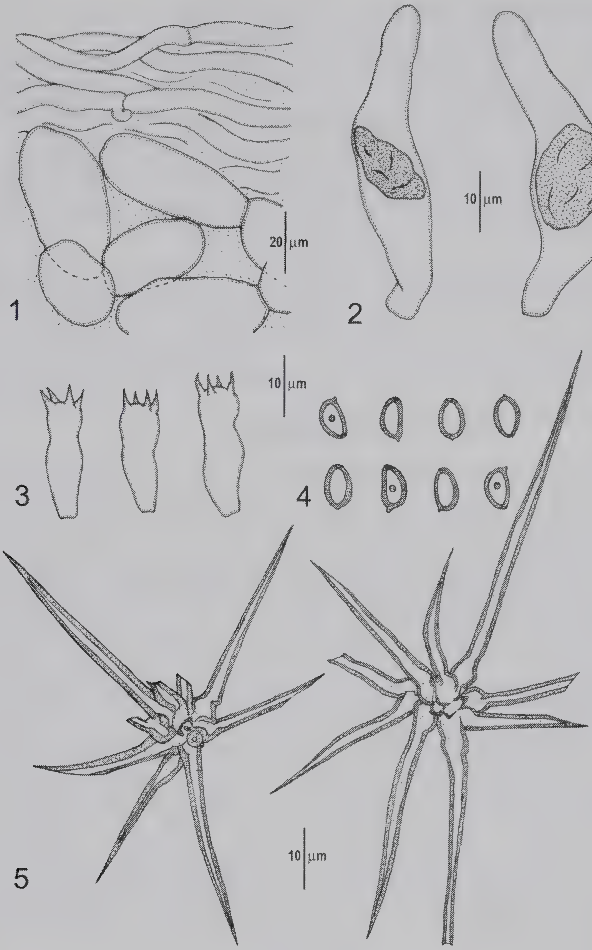
The type specimens received from Kew were in fragments, consisting of pieces of two or three basidiomes. Abundant white rhizomorphs were easily seen on first observation. Pegler (1983), who studied both type and fresh specimens, provided a detailed macroscopic description that noted a 30-75 mm, convex to umbonate, cinnamon-brown to ochraceous-buff, hygrophanous pileus with white velar remnants appendiculate on the margin; adnate, pale grey to tobacco-brown, moderately crowded lamellae; a 30–50 × 5–8 mm, cylindrical, ochraceous cinnamon, striate stipe with abundant white rhizomorphs at the base; a cream colored, fibrillose to floccose veil forming an indistinct annular zone on upper stipe; and a dark maroon.

Prior to examination, thin sections of dried basidiomes from the holotype were mounted in 5% KOH and 1% Congo red solutions. The following characters were observed:

BASIDIOSPORES 6–7.5 × 3.7–4.6(–5) μm, Q= 1.45–1.78, Q_m= 1.65, n= 42, elliptic to phaseoliform in side view, ovoid to elliptic in frontal view, with a smooth and thick wall, and a reduced germ-pore (Fig. 4); BASIDIA 17–21 × 6–7.5 μm, subclavate, with a medial constriction, 4-spored (Fig. 3); PLEUROCYSTIDIA 38–59 × 10–14.2 μm, as chrysocystidia, lageniform to ventricose, with rounded apex, not mucronate, thin-walled, with greenish amorphous contents (Fig. 2); CHEILOCYSTIDIA not found, probably collapsed – according to Pegler (1983) they are 22–27 × 10–17 μm, pyriform to globose, hyaline, and thin-walled, not of the chrysocystidia type; PILEIPELLIS composed of hyaline, smooth and thin-walled hyphae, 6–9.5 μm diam. on a hypodermium formed by brownish, inflated hyphae, 14–25 μm diam. (Fig. 1); HYMENOPHORAL TRAMA subregular, composed by yellowish interwoven hyphae; CAULOCYSTIDIA 27–47 × 9–12 μm, as chrysocystidia, scattered or in fascicles on stipe apex, and similar to the pleurocystidia; ACANTHOCYTES very abundant on rhizomorphs surface (Fig. 5).

The combination of the above characters makes generic assignment in *Strophariaceae* difficult, for the spore print suggests *Pholiota* while the subcellular hypodermium is more closely related to *Hypholoma* (= *Naematoloma*). However, the presence of acanthocytes easily supports placement of the species in *Stropharia*. This morphological feature, which is unique to the genus (Farr 1980), has been recently useful in diagnosing other *Stropharia* species (Cortez 2008; Cortez & Silveira 2007, 2008; Desjardin & Hemmes 2001; Norvell & Redhead 2000). Recent research (Luo et al. 2006) suggests that in *S. rugosoannulata* Farl. ex Murrill acanthocytes function as a nematode-attacking device unique to the genus.

Pholiota trinitensis must be compared with other neotropical members of *Stropharia* previously classified in *Pholiota* section *Albivelatae* A.H. Sm. & Hesler, including *S. apiahyna* (Speg.) Cortez & R.M. Silveira and *S. varzeae* (Singer) Cortez. *Stropharia apiahyna* differs in producing a smaller pileus (< 30 mm), a membranous annulus, and longer cheilocystidia (Cortez & Silveira 2008). *Stropharia varzeae,* which also has membranous annulus, produces cheilocystidia as chrysocystidia (Cortez 2008). *Stropharia acanthocystis* Cortez & R.M. Silveira, from *Araucaria angustifolia* (Bertol.) Kuntze forests in south Brazil, is similar in basidiospore size and cheilocystidial shape. However, in *S. acanthocystis* the cheilocystidia have thickened walls, pleurocystidia are



Figs. 1-5. *Stropharia trinitensis* – Holotype: K(M) 147682.
1. Pileipellis and hypodermium. 2. Pleurocystidia. 3. Basidia. 4. Basidiospores 5. Acanthocytes.

clavate, caulocystidia are of three types (leptocystidia, chrysocystidia, and acanthocytes), and (unique within *Stropharia*) acanthocytes are also present as hymenial cystidia (Cortez & Silveira 2007).

Naematoloma amazonicum Singer, described by Singer (1973) from Brazil, was considered by Pegler (1983, as *Hypholoma*) and Singer (1986, as *Naematoloma*) as a synonym of *P. trinitensis*. This synonymy only will be confirmed after the study of the holotype of *N. amazonicum*.

Based on all above cited characters, *P. trinitensis* is considered a good species of *Stropharia* and the new combination is introduced:

Stropharia trinitensis (Dennis) Cortez, **comb. nov.**

MycoBank MB 511476

Basionym: *Pholiota trinitensis* Dennis, Kew Bull. Add. Ser. 3: 467, 1970.

Synonyms: *Hypholoma trinitense* (Dennis) Pegler, Kew Bull. Add. Ser. 9: 509, 1983.
Naematoloma trinitense (Dennis) Singer, Agar. Mod. Taxon.: 564, 1986.

Examined specimen: TRINIDAD ISL. St. Augustine, 27.IX.1949, *R.W.G. Dennis 78* – K (M) 147682 (***holotype***).

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Ambispora brasiliensis, a new ornamented species in the arbuscular mycorrhiza-forming *Glomeromycetes*

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Abstract — A new dimorphic fungal species in the arbuscular mycorrhiza-forming *Glomeromycetes* was found in the Cerrado biome in Minas Gerais (Southeast Brazil) and is here described from acaulosporoid glomerospores under the epithet *Ambispora brasiliensis*. Glomoid glomerospores of this species were found only once, connected to a germinating acaulosporoid glomerospore. The acaulosporoid glomerospores are formed on a pedicel branching from the neck of a sporiferous saccule. They are hyaline to pale yellow in color, globose, 62–95 µm in diameter, to subglobose to oval, 59–88 × 69–100(–118) µm, and with three spore walls. Crowded irregular pustules, 2.4–7.0(–10.0) µm high and 4.2–9.8(–15.0) µm wide, are formed on the surface of the outer wall. The glomoid glomerospores are hyaline to subhyaline, globose, 25–30 µm in diameter, and have a bi-layered spore wall without ornamentation. The acaulosporoid glomerospores of the new fungus can easily be distinguished from all other species in the genus *Ambispora* by spore size and by the distinct pustulate ornamentation.

Key words — *Glomeromycota*, *Ambisporaceae*, bimorphic, germination

Introduction

Species of the genus *Ambispora* C. Walker et al. of the arbuscular mycorrhiza (AM) forming *Ambisporaceae* C. Walker et al. (*Glomeromycetes*) can form acaulosporoid and glomoid glomerospores (Spain et al. 2006, Walker et al. 2007a, Walker 2008). For some species only the acaulosporoid morph is known (e.g. *A. jimgerdemannii* (N.C. Schenck & T.H. Nicolson) C. Walker), for others only the glomoid morph (e.g. *A. leptoticha* (N.C. Schenck & G.S. Sm.) C. Walker et al. and *A. callosa* (Sieverd.) C. Walker et al.), while at least *A. appendicula* (Spain et al.) C. Walker, *A. gerdemannii* (S.L. Rose et al.) C. Walker et al. and *A. fennica* C. Walker et al. definitely form both morphs (Spain et al. 2006, Walker et al. 2007a, Walker 2008). There has been some confusion regarding the valid taxonomic nomenclature of *Ambisporaceae* and its type genus *Ambispora* in the recent literature resulting from past incorrect re-combinations and synonymies (see review by Spain et al. 2006), or obviously illegitimate names attributed by Spain et al. (2006) at the genus level (see Walker et al. 2007a,b, 2008).

Acaulosporoid glomerospores of *Ambispora* can quite easily be recognized by their morphology (Spain et al. 2006) whereas the glomoid morph might be mistaken with glomerospores of the *Glomeraceae*. Indeed, Walker et al. (2007a) identified *Glomus callosum* Sieverd. as belonging to *Ambispora* only using molecular biological techniques.

Acaulosporoid glomerospores of an undescribed *Ambispora* species were detected in rhizospheric soil from a natural ecosystem of the Brazilian Cerrado biome in Serra do Cipó (Minas Gerais State, Southeast Brazil). The species, characterized by a distinct pustulate ornamentation on the outer spore wall, is presented here under the epithet *Ambispora brasiliensis*.

Material and methods

Soil sampling and culturing of AM fungi

Soils were sampled in the Cerrado biome of Serra do Cipó (Minas Gerais State, Brazil) from the rhizosphere of typical native plant vegetation, mainly consisting of *Vellozia caruncularis* Mart. ex Seub., in July 2004. The site is located at 19° 06'S and 43° 35'W. Soil pH (H_2O) was 4.7.

For culturing the native AM fungal communities, 50 g of the field soil were mixed with 400 g autoclaved sand-vermiculite substrate (1:1 w/w, pH 5.5) and filled into 500 ml pots. *Sorghum bicolor* (L.) Mönch was used as bait plant. The culture pots were maintained at the greenhouse of the Department of Mycology, Universidade Federal de Pernambuco, Recife. Additionally, multiple glomerospores of the new species were separated and used as infective propagules in single species cultures using the same pot size and sand-vermiculite culture substrate as described above. So far, all trials failed to establish a successful symbiosis with the new AMF species both in bait cultures and in single species cultures.

Morphological analyses

Acaulosporoid glomerospores were extracted from field soils and the culture substrates by wet sieving (Gerdemann & Nicolson 1963) and sucrose centrifugation (Jenkins 1964). The spores were thereafter isolated under a stereo microscope and mounted in polyvinyl-lacto-glycerol (PVLG), PVLG + Melzer's reagent (Brundrett et al. 1994) and in water, respectively. For the description of the glomerospores and the spore walls, the terminology of Spain et al. (2006) recently presented for species of the genus was used. We use the term glomerospore for all spores formed by species of the *Glomeromycetes*, as proposed by Goto & Maia (2006).

Description of the new species

Ambispora brasiliensis B.T. Goto, L.C. Maia & Oehl, **sp. nov.** **Figs. 1–9**
MycoBank MB 511612

Sporocarpia ignota. Sporae dimorphae; sporae acaulosporoideae hyalinae vel subhyalinae, globosae (62–95 µm in diametro) vel subglobosae vel ovales (59–88 × 69–100(–118)) µm, cum ternibus tunicis stratis pluribus, in solo singulatim formatae appendice lateraliter ex hypha terminata in sacculo sporangifero; sporae cum tunica exterior, tunica media et tunica interior: tunica exterior tunica mediaque coniuncta sacculi et hyphae; tunica exterior stratis tribus in totum 2.7–3.8 µm crassa, stratum exterius tunicae exterioris hyalinum, evanescens, 0.4–0.7 µm crassum; stratum secundum hyalinum at flavo-pallidum, 2.2–3.2 µm crassum, pustulibus irregularibus ornatum altis 2.4–7.0(–10)µm et 4.2–9.8(–15) µm latis ornatum; stratum interius tunicae exterioris hyalinum at flavor-pallidum, subtile; tunica media duobus stratis hyalinis in totum 2.8–5.2 µm crassa; tunica interior de novo formans stratis duabus vel tribus, in totum 2.2–2.9 µm crassa. Sporae glomoidae hyalinae vel subhyalinae, 25–30 µm in diameterum, stratis duobus. Holotypus hic depositus 78879: URM.

Etymology: *brasiliensis* referring to Brazil, the country where the species was found.

Glomerospore formation. Sporocarp formation is unknown. The species is dimorphic producing acaulosporoid and glomoid morphs. Acaulosporoid glomerospores form singly in soils upon a short pedicel arising laterally on the tapering hyphal neck of a sporiferous saccule (Figs. 1–3). The acaulosporoid glomerospores form three spore walls: an outer wall (ow), a middle wall (mw) and an inner wall (iw) (Figs. 4–9). Glomoid glomerospore formation was observed once on a hypha connected to a germinating acaulosporoid morph.

Sporiferous saccule of acaulosporoid glomerospores are hyaline to light yellow, globose to subglobose, 65–115 µm in diameter and formed terminally on a hypha (Figs. 1–2). The saccule wall generally is bi-layered with a hyaline to light yellow, rapidly degrading, evanescent outer layer (0.5–0.9 µm thick) and a hyaline to subhyaline, semi-persistent inner layer (0.6–1.5 µm thick). The hyphal neck of the sporiferous saccule is 10–17 µm wide at the saccule base tapering to 8–12 µm at the point where the pedicel of the acaulosporoid glomerospore branches, narrowing further to 5–8 µm at a distance of 40–120 µm from the pedicel. A septum arises in the tapering hyphal neck distal to the saccule where the pedicel forms. The sporiferous saccule generally collapses and detaches from the mature spore while the pedicel often persists on the glomerospore.

Acaulosporoid glomerospores form singly on a short hyphal pedicel (Fig. 3). The spores are globose (62–95 µm in diameter) to subglobose to oval, 59–88 × 69–100(–118), hyaline to subhyaline in water and generally become light yellow to ochre-yellow in PVLG-based mountants. The two wall layers of the saccule continue on the glomerospore differentiating into two separate glomerospore walls: a two to three layered outer wall (ow) and a bi-layered middle wall (mw).

A two-to-three layered inner wall (iw) forms de novo, presumably after the spore pore has been closed by the inner layer of the middle wall (mwl2) which differentiates from mwl1. The iw functions as a germinal wall.

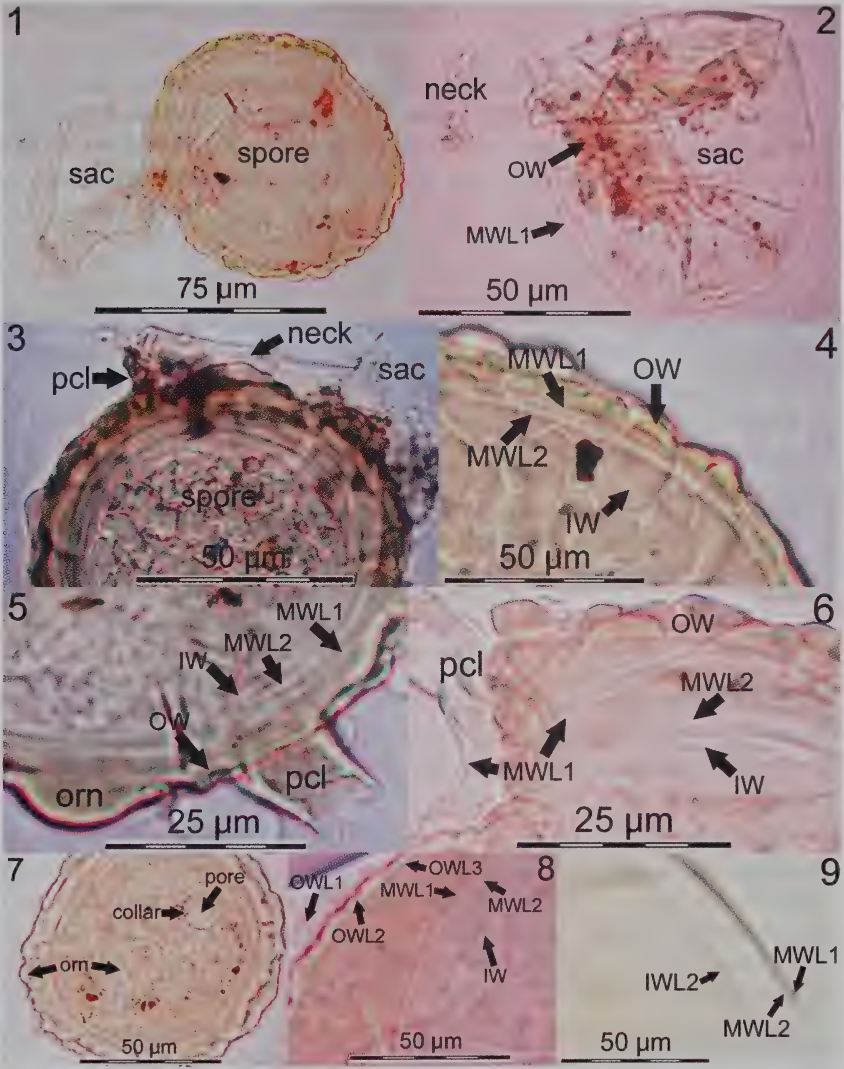
Outer wall generally consists of three layers (Figs. 4–8). The outer layer (owl1) is hyaline to subhyaline, evanescent, 0.4–0.7 µm thick, and often is difficult to detect, as it tightly adheres to owl2 (Fig. 8). owl2 is hyaline to light yellow and in total 2.2–3.2 µm thick and crowded with conspicuous, convex pustules (Fig. 3–8). The pustules vary greatly in shape and size and are generally 2.4–7.0(–10) µm wide and 4.2–9.8(–15) high (Figs. 4–7). The inner layer (owl3) is thin (0.3–0.6 µm), hyaline to subhyaline and tightly attached to owl2 making it difficult to detect. In older spores, the outer wall might degrade completely, but usually some fragments remain on the surface of the middle wall.

Middle wall is bi-layered and in total 2.8–5.2 µm thick (Figs. 4–6; Figs. 8–9). mwl1 is hyaline, 1.3–2.6 µm thick and continuous with the persistent inner layer of the pedicel. A septum arising in the pedicel from mwl1 during spore formation was rarely detected. mwl2 is also hyaline, 1.5–2.6 µm thick, tightly adherent to mwl1 and generally closes the pore of the pedicel.

Inner wall is hyaline and three-layered but generally only the central layer (iwl2; Figs. 4–6; Fig. 8–9) or the inner two layers (iwl2 and iwl3) are visible. The outer layer iwl1 is 0.3–0.6 µm and difficult to detect, as it is tightly adherent to the central layer iwl2 which is 1.5–2.2 µm thick. The innermost layer is 0.4–0.8 µm thick and also tightly adherent to iwl2 but sometimes separates slightly showing several thin folds when pressure is applied.

Pedicel of acaulosporoid glomerospore branches from the hyphal neck of the sporiferous saccule in about 40–130 µm distance from the globose saccule terminus. The pedicel is (5–)7–16(–25) µm long, and 8–13 µm wide at the glomerospore base tapering to 5–9(–13) µm at the connection to the hypha. The two wall layers of the hyphal neck of the sporiferous saccule differentiate into the outer and the middle wall of the pedicel (ow and mw). On mature spores, the pedicel often persists resembling a subtending hypha of glomoid glomerospores (Fig. 5). Sometimes only the ow (Fig. 5) or the mw (Fig. 6) of the pedicel persist on the spore; rarely both pedicel walls are found on mature glomerospores. The ow sometimes forms a collar (Fig. 7) on the glomerospore (8.5–14 µm in diameter). The ow, if present on the pedicel, is 1.2–2.5 µm thick at the glomerospore base tapering to 0.5–0.9 µm towards the saccule neck. The mw is 1.3–2.1 µm at the glomerospore base tapering to 0.9–1.5 µm.

Glomoid glomerospores were detected only once on a connecting hypha about 250 µm from a germinating acaulosporoid glomerospore. The hyaline to subhyaline glomoid glomerospores were bi-layered and about 25–30 µm in diameter. The glomerospore wall was 1.9–2.5 µm thick in total, and the


1
sac
spore
75 µm
2
neck
OW
sac
MWL1
50 µm
3
neck
pcl
sac
spore
50 µm
4
MWL1
OW
MWL2
IW
50 µm
5
MWL1
MWL2
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6
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OWL3
8
MWL1
MWL2
OWL2
IW
50 µm
9
MWL1
IWL2
MWL2
50 µm

Figs. 1–9: *Ambispora brasiliensis* forming acaulosporoid glomerospores with three walls (outer wall OW, middle wall MW and inner wall IW) upon a short pedicel arising laterally on the neck of a sporiferous saccule. **Fig. 1.** Acaulosporoid glomerospore and sporiferous saccule (SAC) attached. **Fig. 2.** Saccule with two layers: evanescent outer layer continuous with OW of the spore and semi-persistent inner layer continuous with MWL1 of the acaulosporoid spore. **Fig. 3.** Pedicel (PCL) and degrading saccule. **Figs. 4–6.** Irregular pustulate ornamentation (ORN) on middle layer of OW; MW has two layers (MWL1 + MWL2). **Fig. 5.** Pcl wall continuous with OW. **Fig. 6.** Pcl wall continuous with MWL1. **Fig. 7.** Glomerospore pore and collar formed on OW. **Figs. 8–9.** Spore wall structure: OW with three layers (evanescent OWL1, pustulate OWL2; OWL3 hardly detectable), MW bi-layered (MWL1 + MWL2); only central layer evident on IW.

subtending hypha was 2.0–3.1 µm wide at the base of the glomerospore, where a septum was not visible.

Germination was observed once on an acaulosporoid glomerospore, where it initiated on the iw below the pedicel collar. Three germ tubes (2.4–4.0 µm wide) emerged from the center of a lobed germination structure, which was 34 × 15 µm in diameter and consisted of 6–7 lobes that were each 12–15 µm long and 5–8 µm wide. The germ tubes had grown through the pedicel collar and branched in about 200–250 µm distance from the glomerospore. However, it was not clearly discernable if the lobed germination structure was formed between iw and mw or between the mw and the collar formed by the pedicel on the ow.

Mycorrhizal formation — unknown.

Distribution — Brazil: so far only found in the Cerrado biome of Serra do Cipó, Minas Gerais State.

Specimens examined — **BRAZIL. Minas Gerais. Serra do Cipó. HOLOTYPE** (54-5401) and type specimens (54-5402) deposited at URM, Recife, Pernambuco, Brazil (accession numbers URM 78879 and 78880). Isotype (54-5402) specimens deposited at OSC, Corvallis, Oregon, USA (accession number OSC# 134501); and 54-5406 & 54-5407, deposited at Z+ZT, Zürich, Switzerland (accession number ZT MYC 159).

Discussion

The new fungal species, *Ambispora brasiliensis*, can easily be identified by its acaulosporoid morph and can be distinguished from all other *Ambispora* species forming acaulosporoid morphs by glomerospore size and by the distinct pustular ornamentation on the acaulosporoid glomerospore walls.

Acaulosporoid glomerospores of other genera in the *Glomeromycetes* — namely *Acaulospora*, *Archaeospora* and *Otospora* (Gerdemann & Trappe 1974, Morton & Redecker 2001, Palenzuela et al. 2008) — cannot be confused with *A. brasiliensis*. Spores of *Archaeospora* and *Otospora* have two walls (Palenzuela et al. 2008) contrasting with *Acaulospora* and *Ambispora*, which have three spore walls (Spain et al. 2006, Walker et al. 2007a, Palenzuela et al. 2007). Glomerospores of *Acaulospora* are not formed on a pedicel (= appendix) as known for the acaulosporoid glomerospore formation of *Ambispora*. Furthermore, in *Acaulospora* the middle spore wall forms de novo (e.g. Oehl et al. 2006) and is not continuous with the wall of the sporiferous saccule as noted for *Ambispora brasiliensis* and other *Ambispora* species (Spain et al. 2006, Walker et al. 2007a). Finally, only three *Acaulospora* species are known to form projections on the outer spore wall: *Ac. spinosa*, *Ac. tuberculata* and *Ac. denticulata*, which form — according to their names — either spiny, tuberculate or dentate ornamentations (Walker & Trappe 1981, Janos & Trappe 1982, Sieverding & Toro 1987) but not convex, irregular pustules as in *A. brasiliensis*.

We found a glomoid morph of this new species connected via hypha to a germinating acaulosporoid morph of *A. brasiliensis* only in one occasion. Such glomoid glomerospore formation during germination of acaulosporoid spores was also found for *A. appendicula* (Spain pers.comm. 2008; Goto & al. unpub. obs.). In addition to the glomoid morph, swollen hyphal tips on mycelia were also noted for *A. appendicula* (Schenck et al. 1984).

We were not able to culture *A. brasiliensis* but hope to conduct genetic analyses as soon as clean cultures are available. However, in the absence of genetic data, *A. brasiliensis* can be identified morphologically by observing its acaulosporoid glomerospores. As stated in the introduction, the glomoid morph of some of the *Ambispora* spp. is still unknown, and, in any case, *Ambispora* is more easily diagnosed by observing the acaulosporoid rather than the glomoid morph.

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Lichens of Malatya, Elazığ and Adıyaman provinces (Turkey)

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Abstract—The lichenized and lichenicolus fungi of Malatya, Elazığ and Adıyaman provinces of Turkey, based on the authors' collections and literature records, are listed, of which 20 are new for Turkey and 187 are new for the study area. As a consequence of this study, there are 315 infrageneric taxa recorded from these provinces. The full Checklist can be viewed at http://www.mycotaxon.com/resources/weblist.html

Key words—lichenized fungi, new records, biodiversity

An increasing number of studies on the lichen flora of Turkey have been carried out in the last two decades, most focused on central, western and northern Turkey where even today some areas remain unexplored. The present floristic study of the previously overlooked Malatya, Elazığ and Adıyaman provinces redresses to some extent this situation.

The first lichen records of six independent researchers from the study area, concerned with the distribution and uses of manna lichens undertaken during 1864-1897, are reviewed by Donkin (1981). Steiner (1921) reported 74 taxa from Elazığ and Adıyaman provinces, based on Handell-Mazetti's collections from Mesopotamia, Syria and Iraq. Szatala (1960) recorded 8 lichens from Elazığ Province, as well as records from other parts of Turkey. Szatala's paper (1960) based on the lichen collection of zoologist Victor Pietschmann, all contained lichen records from Syria and Iraq. Recently, Candan & Özdemir Türk (2000) recorded 50 infrageneric taxa from eastern part of Malatya City. Other records for the study area are two exsiccates (Lumbsch & Feige 1999, John 1999), two by Degelius (1954), one by Steiner & Poelt (1982), one by Timdal (1991) and new lichenicolous fungi by Halıcı et al. (2007a,b) and Halıcı & Candan (2007).

As in other parts of Turkey, the natural vegetation of Malatya, Elazığ and Adıyaman provinces has been subjected to anthropogenic stress for many years, mainly due to heavy grazing, afforestation, farming and urbanisation. Furthermore, many large dams have been built in southeastern Anatolia during the last 30 years and others are currently under construction. Hence, a relatively large portion of the study area is covered by dam lakes. As well as determining the current lichen

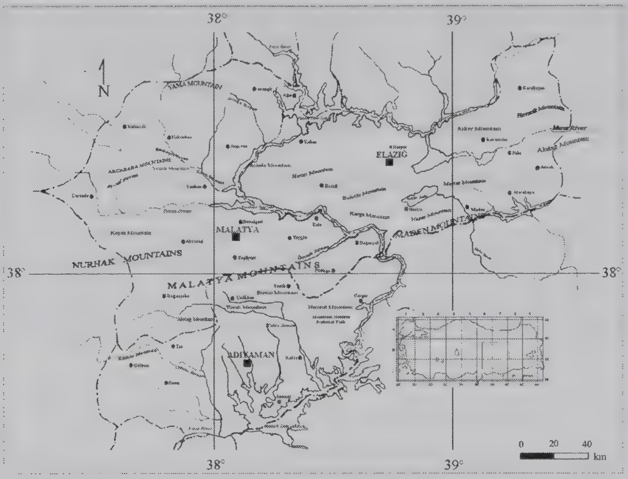

Figure 1. Map of the study area

diversity of Malatya, Elazığ and Adıyaman provinces, this article also includes previous records from the region dating back to the 1860s. It is also hoped that this study will provide a database for monitoring the effects of the climate change on the lichen flora due the development of dams and their resultant lakes.

Study Area: Malatya, Elazığ and Adıyaman provinces are located in Anatolia and are part of the Irano-Turanian Phytogeographical Region of Turkey. According to Davis (1965), Malatya and Elazığ are in the Upper Euphrates and Adıyaman is in the Mesopotamian area. The study area (Fig. 1) is located between 37°25' 39°11' N and 37°25' 40°21' E at altitudes ranging from 500 m in the south of Adıyaman Province to 2650 m in the Malatya Mountains lying on the border of Adıyaman and Malatya provinces. The northern part of the study area, including Malatya and Elazığ provinces, is mainly covered by highlands, the lowest altitudes of c. 800 m being found in valleys.

The study area also covers the eastern side of the Nurhak Mountains, the Malatya Mountains, the Maden Mountains and Akdağ located in the Southeast Taurus Mountains, the highest altitudes being the summits of Akdağ (2650 m), Bey (2545 m), Hazar (2347 m), Akçababa (2052 m) and Hasan (1864 m). The south side of Yama Mountain (2402 m), situated between Malatya and Sivas provinces, is also included in the study area. The Upper Fırat, Tohma Stream, Sürgü Stream, Sultan Creek, Murat, and Dicle Valleys are located between the high mountains. Although Hazar Lake is the largest natural lake in the area, the lakes of Keban, Karakaya, Atatürk, Sürgü and Çat Dams cover a much larger area collectively.

The rich topographical diversity of the study area provides varied climatic conditions, which are further modified the effects of the dam lakes; to date, no research has been carried out to determine these effects. The study area has a Meditteranean climate. According to Emberger's principles, Akman (1990) reported that precipitation-temperature coefficients (Q_2) are 36.2, 39.6 and 75.4 and aridity indices (S) are 0.7, 0.5 and 0.2 for Malatya, Elazığ and Adıyaman provinces, respectively.

The dominant vegetation of the region is steppe in character. For anthropological reasons, no large forests are to be found in the study area; *Quercus* spp. are sparsely distributed. The most eastern distribution of *Pinus brutia* Ten. in Turkey is located at the junction of the borders of Kahramanmaraş, Malatya and Adıyaman provinces which coincides with the southeast part of the study area. In spite of poor forest cover, there is intensive apricot (*Prunus armeniaca* L.) agriculture in some parts of Malatya Province and pistacio (*Pistacia vera* L.) agriculture in Adıyaman Province. Wild *Prunus*, *Crataegus* and *Rosa* spp. are also common in the study area, and *Salix* spp., *Populus* spp., and *Platanus orientalis* L. are found in the wet habitats such as valleys.

METHODOLOGY: This study is based on an evaluation of the authors' lichen collections made between 2003 and 2005 and on literature sources relating to Malatya, Elazığ and Adıyaman provinces of Turkey. The specimens were examined with a Leica MZ6 stereomicroscope and an Olympus BX51 microscope with standard identification methods for lichens and lichenicolous fungi (Purvis et al. 1992, Wirth 1995). Also TLC analyses of the specimen were carried out when needed. Voucher specimens are stored in ANES (Herbarium of Anadolu University, Anadolu University, Faculty of Science, Eskişehir, Turkey).

CONCLUSIONS: Twenty of the lichens in the Checklist are new for Turkey: *Acarospora macrospora* subsp. *murorum*, *A. peliscypha*, *Aspicilia emiliae*, *Buellia imshaugii*, *B. pulverulenta*, *Caloplaca erodens*, *Dermatocarpon rivulorum*, *Fulgensia pruinosa*, *Immersaria usbekica*, *Lecanora laatokkaensis*, *L. reuteri*, *Placidiopsis custnani*, *Placidium tenellum*, *Polyblastia albida*, *Rinodina interjecta*, *R. luridata*, *R. roscida*, *Staurothele bacilligera*, *Thelidium incavatum*, and *Xanthoparmelia glabrans*.

According to the literature, 128 lichens and lichenicolous fungi have been previously recorded from the study area. As a consequence of this study, this number has increased to 315. However, some early papers (Donkin 1981, Steiner 1921, Szatala 1960) provide only vague locality details (many of which have changed their names), making it difficult to evaluate distributional changes of lichens.

The study area is a transition region between the Mediterannean and the Irano-Turanian Phytogeographical Regions, the western and southwestern parts bordered by the former in Turkey where the distribution of *Pinus brutia* ends. This is why some authors delimit this region by the distribution of *P. brutia* while others delimit it by the Mediterranean sclerophyll forests, but both have very similar phytogeographical boundary.

Because of the interesting geographical position of the study area, lichens commonly distributed in Central Asia, Middle East and Europe also occur with local lichens, leading to a rich lichen diversity. Furthermore the altitude of the study area starts from 500 m in Adıyaman Province and 800 m in Elazığ Province, and reaches higher than 2000 m in some localities. Therefore, high mountain lichens also make a significant contribution to the lichen flora of the area. However, lichen diversity is modified by the limited forest cover which reduces humid and shade loving species; most lichen epiphytes grow on free-standing trees and are nitrophilic and heliophilic.

Acknowledgements

We are grateful to Prof. Mark R. D. Seaward for linguistic revision, helpful comments and reviewing the manuscript, to Dr. P. Divakar for reviewing the manuscript and to the authors whose names are indicated in the List of Taxa. This study was funded by Anadolu University Scientific Research Project Unit (grant no. 031043).

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MYCOTAXON

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Two new anamorphic rust fungi from northern areas of Pakistan

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Abstract — Two anamorphic rust fungi, *Aecidium pakistanicum* on *Spiraea tomentosa* and *Aecidium ikramii* on *Rosa* sp. are described as new. These new discoveries raise the total of known rust taxa in northern Pakistan to forty-four.

Key words — *Basidiomycota*, new taxa, *Phragmidium tuberculatum*

Introduction

Northern areas of Pakistan are bounded by Afghanistan, People's Republic of China, Indian-held territory of Kashmir and North West Frontier Province of Pakistan. The southern slopes near Kashmir lie within the Himalayan mountain system. Snow covered mountains with deep gorges and narrow valleys surround the area. Climatic conditions vary widely in the northern areas, ranging from monsoon influenced moist temperate zone in western Himalayas to arid and semi-arid cold desert in the northern Karakoram and Hindu Kush. Temperature in the valley bottoms can vary from extremes of 40°C in summer to less than 10°C in winter (Jacobose 1993).

The rust fungi of Northern areas of Pakistan are poorly known and only forty-two rust taxa have been published from the region so far (Ahmed 1956a, b;

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*Author for correspondence

Gjaerum & Iqbal 1969, Kaneko 1993, Kakishima et al. 1993, Khalid et al. 1995, Khalid & Iqbal 1996a, b, 1997; Ahmed et al. 1997).

This paper reports two anamorphic rust fungi collected on rosaceous plants, *Spiraea tomentosa* L. and *Rosa* sp., from northern areas of Pakistan during 2001-02

Materials and methods

The host plants, *Spiraea tomentosa* and *Rosa* sp. were found infected with rust fungi. *Aecidium pakistanicum* on *S. tomentosa* from Fairy-meadows on July 22, 2001 and *Aecidium ikramii* on *Rosa* sp. from Bashu Jungle, Skardu, on October12, 2002 were collected by the senior author.

Dried herbarium materials were examined under light microscope and Scanning Electron Microscope (SEM). For LM observations, the hand sections and spores were mounted in a drop of Lactophenol solution on glass slides, gently heated to boiling point and then cooled. The measurements of spores are given in the form: min-max (mean = 1 standard division). The sections showing rust stages were observed under a microscope (NIKON YS 100) and micro photographed by Canon AE-1 programmed camera. For SEM the spores were attached to specimen stub in a drop of acetone and coated with carbon with Joel Jee-420 evaporator. The surface structure of spores was observed at 10 kV and photographed with Joel Jsn-6480 LV SEM.

Enumeration of taxa

Aecidium pakistanicum Sultan, I.U. Haq, Khalid & Mukhtar, **sp. nov.**

MycoBank MB 511527 **(Plate 1, Figs A, C)**

Pycnia epiphylla, brunneis, dispersa, 0.1-0.2 mm. Aecidia hypophylla, dispersa, aggregate, revoluto, 0.2-0.7 mm, brunneis, peridio longo, hyalinae, cellula peridii ellipsoideae, 68-88 × 15-19 µm, pariete externo 3.5-5.5 µm crasso, verrucoso, pariete interno 5.0-7.5 µm crasso, verrucoso, Aecidiosporae 34-36 × 26-28 µm, globosae vel subglobosae, ellipsoideae, hyalinae, brunneis, verruculoso, Poris obscures. Uredinia et telia ignota.

Holotype: On *Spiraea tomentosa* L., with 0 & 1 stages, Northern Pakistan, Fairy-Meadows, July 22, 2001, M.A. Sultan (LAH Herbarium # AS 41, Isotype GCU Herbarium).

Etymology: Based on the name of country Pakistan.

Pycnia epiphyllous, brown, scattered, 0.1-0.2 mm. Aecia hypophyllous, scattered, sori appear aggregate, in groups, revolute, 0.2-0.7 mm, brown, peridia long, hyaline. Peridial cells (Fig 1A) ellipsoid, 68-88 × 15-19 µm, outer wall 3.5-5.5 µm thick, verrucose, inner wall 5.0-7.5 µm thick, verrucose. Aeciospores (Fig 1B) 34-36 × 26-28 µm, globose to subglobose, ellipsoid, hyaline, brown, densely and finely verruculose, pores obscure. Uredinia and telia unknown.

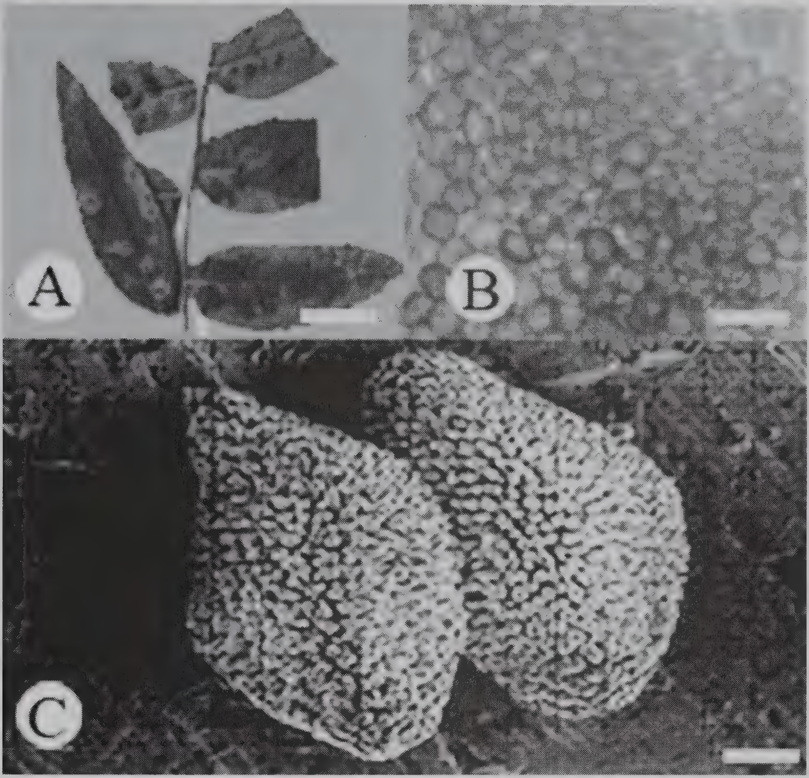

Plate 1. Figs. A-B: *Aecidium pakistanicum* on *Spiraea tomentosa* (A) Infected host plant Bar = 2.0 cm. (B) Aeciospores in Light microscope Bar =160 μm. (C) Verruculose aeciospores in SEM. Bar = 18 μm.

COMMENTS — *Aecidium pakistanicum* is unique among the known species of *Aecidium* in having a sac-like sorus and verruculose aeciospores. These characteristics separate *A. pakistanicum* from fourteen (Sato & Sato 1984) described aecium types. *A. pakistanicum* resembles none of the aecial types described so far.

Aecidium haqii Sultan, Khalid & Mukhtar, **sp. nov.** **Plate 2, Figs. A-C**

MYCOBANK MB 511528

Spermogonia, uredinia et telia ignota. Aecidia hypophylla, dispersa, aggregate, caeomoidea, paraphysibus peripheralis, flavida, 0.1-0.2 mm. Aecidiosporae globosae vel subglobosae, ellipsoideae, hyalinae, 20-26 × 19-25 μm, clavo superne granulis refractivis, parietibus usque ad 1μm crassis, poris obscures.

Holotype: On *Rosa* sp., with I stage, Northern Pakistan, Bashu Jungle near Skardu, October 12, 2002, M.A. Sultan (LAH Herbarium # AS 39, Isotype GCU Herbarium)

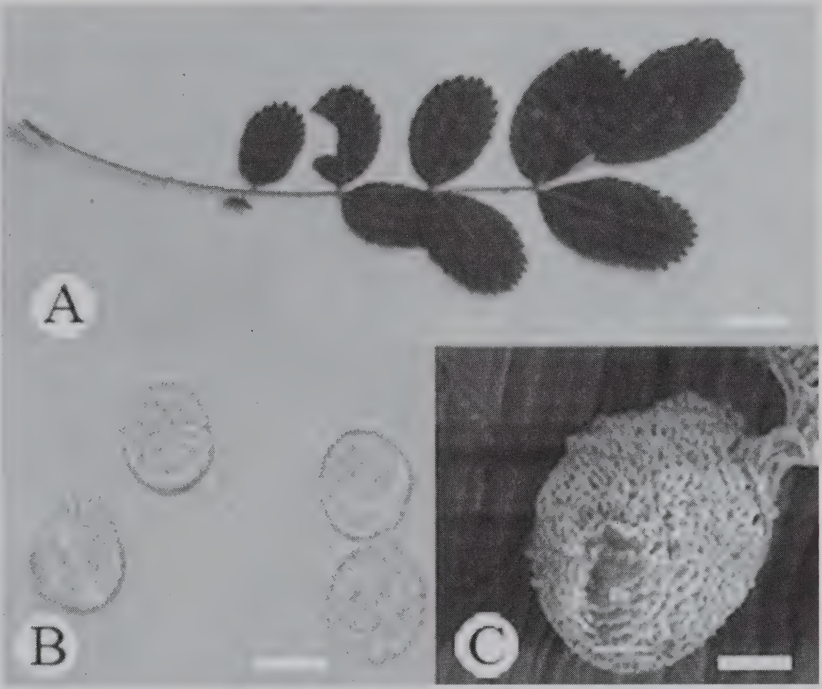

Plate 2. Figs. A-C: *Aecidium haqii* on *Rosa* sp. (A) Infected host plant Bar = 2 cm. (B) Aeciospores in Light microscope Bar = 2 µm. (C) Annulate aeciospores in SEM. Bar = 6.0 µm

Etymology: In honor of the renowned botanist Prof. Dr. Ikram-ul-Haq.

Spermogonia, uredinia and telia unknown. Aecia hypophyllous, scattered, in groups, caeomoid, paraphysis peripheral, yellow, 0.1-0.2 mm. Aeciospores (Fig 2) globose, subglobose, ellipsoid, hyaline, 20-26 × 19-25 µm, annulate, wall 1 µm thick, pores obscure.

Additional specimens examined: LAH # 14131, 14132 S. Ahmed, on *Rosa webbiana* Wall. ex Royle, Kaghan Valley August 28, 1949.

Aecidium haqii was found on an unidentified *Rosa* species lacking thorns and with small leaves. The new species closely resembles *Aecidium* of *Phragmidium tuberculatum* J.H.H. Müll. Both have a caematoid aecidium and similarly sized aeciospores (see Wilson & Henderson 1966). Both species can be clearly differentiated on the basis of wall ornamentation of aeciospores. In *P. tuberculatum* the aeciospores are verrucose and in *Aecidium haqii* aeciospores are annulate.

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A new species of *Isaria* isolated from an infected locust

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Abstract — *Isaria locusticola* sp. nov. was isolated from a locust in Fuzhou, Fujian Province, China. The new species is described and illustrated, and its relationships to the related species are briefly discussed. This fungus is characterized by the variability of the shape of conidia. Morphological characteristics and molecular analyses of ITS-5.8S region sequences strongly support the establishment of *I. locusticola* in the genus *Isaria*.

Key Words — hyphomycetes, *Paecilomyces*, entomopathogenic fungi, morphology, rDNA analysis, *Orthoptera*

Introduction

Hodge et al. (2005) reviewed the nomenclatural status and history of the generic name *Isaria* and concluded that *Isaria* Pers. is a valid name. Consequently, they suggested that the name *Isaria* be used for those species previously assigned to *Paecilomyces* Bainier section *Isarioidea* Samson. Luangsa-ard et al. (2005) accepted this suggestion based on their molecular analysis and accepted 10 *Paecilomyces* species having *Cordyceps* teleomorphs as belonging in the genus *Isaria*. These species were *I. farinosa* (Holmsk.) Fr., *I. amoenerosea* Henn., *I. cateniannulata* (Z.Q. Liang) Samson & Hywel-Jones, *I. cateniobliqua* (Z.Q. Liang) Samson & Hywel-Jones, *I. cicadae* Miq., *I. coleopterorum* (Samson & H.C. Evans) Samson & Hywel-Jones, *I. fumosorosea* Wize, *I. ghanensis* (Samson & H.C. Evans) Samson & Hywel-Jones, *I. javanica* (Frieder. & Bally) Samson & Hywel-Jones and *I. tenuipes* Peck. They also suggested that both *P. ramosus* Samson & H.C. Evans and *P. xylariiformis* (Lloyd) Samson belonged to *Isaria*.

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So far, more than 12 entomogenous species related to *Paecilomyces* have been assigned to *Isaria*.

Species of *Paecilomyces* are considered the most important pathogens parasitizing lepidoptoran insects (Evans & Samson 1982, Kubátová & Dvořák 2005). Species that parasitize orthopteran insects, however, have been rarely reported. Evans was the first to isolate fungus *P. reniformis* Samson & H.C.Evans from an infected grasshopper (*Tettigoniidae, Orthoptera*) (Samson 1974); the same fungus has been also recently isolated from long horned grasshoppers (*Tettigoniidae, Orthoptera*) in Sulawesi, Indonesia (Kalkar et al. 2006). Liang et al. (1991) described *Paecilomyces atrovirens* Z. Q. Liang & A.Y. Liu from an infected *Tettigonia* from Guizhou Province, China. During recent research on Chinese entomogenous fungi, the authors discovered an undescribed *Isaria* species from Fujian Province (eastern China), which is described below.

Materials and methods

Sample collection and strain isolation

Strain GZUIFR-Fj0916 was isolated from an infected adult of *Chondracris* sp. (*Acrididae, Orthoptera*) collected in the Fuzhou National Forest Park, Fujian Province. The infected insect collected from the field was first removed soil and other debris. Few conidia were transferred to plates of Martin's medium. Cultures were incubated at 26°C until colonies were developed. Pure cultures having uniform conidiogenous structures from the infected insect were transferred to Sabouraud's slants and stored in the Institute of Fungus Resources, Guizhou University.

Strain identification

The strain was transplanted to Czapek agar and potato dextrose agar (PDA), incubated at 26°C for 14 days, and identified based on colony characters, conidiogenous structures, temperature responses following Brown & Smith (1957) and Samson (1974) and molecular analysis.

DNA extraction

Taq enzyme and dNTP were supplied by Shanghai Sangon. The strain GZUIFR-Fj0916 used for the molecular identification was incubated on Czapek agar. DNA was extracted from the fresh sporulating cultures following Tigano-Milani et al. (1995). The extracted DNA was stored at -20°C.

PCR and ITS rDNA sequencing

The internal transcribed spacer (ITS) region including the 5.8S rDNA was amplified by polymerase chain reaction (PCR) using the primers ITS5 (5'- GGT GAG AGA TTT CTG TGC -3') and ITS4 (5'-TCC TCC GCT TAT TGA TAT GC-3'). After a first denaturation step at 94 °C for 5 min, the amplification reaction was performed for 35 cycles with denaturation at 94°C for 40 s, annealing at 49°C for 40 s, and extension at

Table 1 Fungi used in the study with their GenBank accession numbers

Names	GenBankNo	Name	GenBank No.
Byssochlamys fulva	AY753341	*I. javanica*	AY624186
B. nivea	AY753339	*I. javanica*	DQ403723
Cookeina colensoi	AF394531	*I. locusticola*	EU363501
C. venezuelae	AF394041	*Paecilomyces aerugineus*	AY753346
Cordyceps militaris	AY725790	*P. amoenerosea*	AY624169
C. takaomontana	AY624198	*P. carneus*	AY624170
Isaria japonica	AF200370	*P. marquandii*	AB099511
I. japonica	AY624199	*P. militaris*	EU363502
I. cateniannulata	AF368802	*P. niphetodes*	AY624192
I. cateniannulata	AY624172	*P. penicillatus*	AY624194
I. cateniobliqua	AF368799	*P. purpureus*	EF640809
I. farinosa	AY624179	*P. reniformis*	ARSEF429
I. fumosorosea	AJ608982	*P. reniformis*	ARSEF577
I. ghanensis	AY624185	*P. reniformis*	DQ069283
I. cateniobliqua	AY624173	*I. tenuipes*	AF368808
I. cicadae	AB085887	*P. variotii*	AY373941
I. coleopterorum	AY624176	*P. viridis*	AY624197

72°C for 1 min; followed by a final extension step at 72°C for 10 min. PCR products were purified using the Agarose Gel DNA Purification kit version 2.0 (Takara Company) according to the manufacturer's protocol and were sequenced with the above primers at Beijing Sunbiotech Co. Ltd. The sequence of ITS1-5.8S-ITS2 rDNA region of strain GZUIFR-Fj0916 was submitted to GenBank (accession number: EU363501).

Sequence alignment and phylogenetic analysis

Table 1 lists strains used in the molecular study. Some ITS1-5.8S-ITS2 region nucleotide sequences of representative *Isaria* and *Paecilomyces* species were obtained from GenBank. The sequence of the new species was aligned with related fungi using the Clustal X1.83 computer program for multiple sequence alignment and manually corrected. The phylogenetic tree was constructed by neighbor-joining method (NJ) of MEGA version 3.1 (Kumar et al. 2004). Confidence values for individual branches were determined by bootstrap analysis (1000 replications).

Results and discussion

Taxonomy

Isaria locusticola Z.Q. Liang, X.Y. He & Y.F. Han, sp. nov. Fig. 1

MycoBank MB 511579; GenBank EU363501

In agaro Czapekii, coloniae 40 mm diam,14 diebus ad 26°C, ablae ad luteolum; reversum luteolum. Hyphae septatae, hyalinae. Conidiophora erecta, septata, hyalina. Phialides 4.2–4.8 × 1.2–2 µm, e basi inflata ellipsoida, claviformisa vel cylindricusa in collum longum angustatae. Conidia continua, hyalina, levia, ellipsoidea, (2.4–)3–3.6(–4.2) × (1.2–)1.5–1.8(–2) µm, vel 4.8 × 3 µm; fusiformia vel cylindricusa 3.5–4.5 × 1.2–1.5 µm. Teleomorphosis ignota.

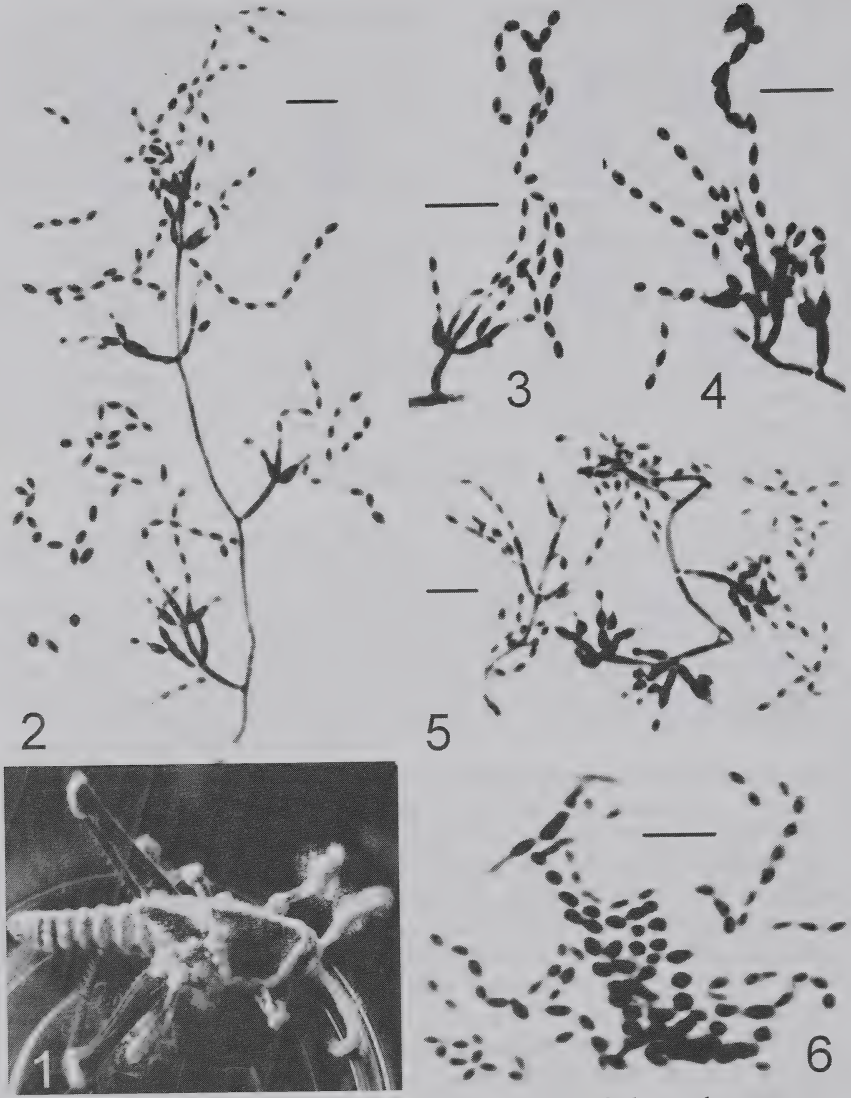

Fig. 1 The host insect and conidiogenous structures of *I. locusticola*.
1. A locust infected by *I. locusticola*; 2–5. The conidiogenous structures; 6. Conidia.

***Holotypus** GZUIFR-Fj016 isolatus, e Chondracris sp. (Acrididae, Orthoptera), Fuzhou regio, Fujian provinca, China. IX, 2007, X.Y. HE et S. P. CAI, in Guizhou Univ, conservatur.*

Colony on Czapek agar, attaining a diameter of 40 mm within 14 days at 26°C, flat, white to yellowish, villiform. Reverse yellowish. Vegetative hyphae hyaline, smooth-walled. Conidiophores septate, forming branches with

Table 2. A comparison of morphological characters between *I. locusticola* and related species

Names	Colony	Conidia	Hosts
P. atrovirens	dark green	cylindrical, 4.2–7.2 × 2.4–3µm	*Tettigonia* sp. (*Acrididae, Orthoptera*)
I. javanica	white	cylindrical to fusiform 5–7.4 × 1.4–1.7 µm	lepidopteran insects
I. locusticola	white-yellowish	ellipsoid 2.4–4.2 × 1.2–2 µm	*Chondracris* sp. (*Acrididae, Orthoptera*)
		fusiform to oblong-ellipsoid 3.5–4.5 × 1.2–1.5 µm	
P. reniformis	greyish-green, olive-green	reniform 4.5–5.5 × 2–3.5 µm	Grasshopper (*Tettigoniidae, Orthoptera*)

phialides in whorls of 2 to 4. Phialides divergent, 4.2–4.8 × 1.2–2 µm, consisting of an ellipsoidal, cylindrical or clavate basal portion and a distinct thin neck. Conidia hyaline, smooth-walled, variable, ellipsoid, (2.4–)3–3.6(–4.2) × (1.2–)1.5–1.8(–2) µm, a few up to 4.8 × 3 µm; fusiform to oblong-ellipsoid, 3.5–4.5 × 1.2–1.5 µm. Bi-celled rare.

Teleomorph: unknown.

Distribution: Fujian Province, China.

Material examined: The holotype, GZUIFR-Fj0916, was isolated by X.Y He & S.P. Cai from an infected cotton grasshopper *Chondracris* sp. (*Acrididae, Orthoptera*), Fuzhou, Fujian Province, China, September, 2007, deposited in the Institute of Fungus Resources, Guizhou University.

The two species of *Paecilomyces* known to infect locusts — *P. reniformis* and *P. atrovirens* (Samson 1974, Liang et al. 1991, Kalkar et al. 2006) — distinctly differ from *I. locusticola* (Table 2). *P. reniformis* produces grayish-green or olive-green colonies and reniform conidia, while *Isaria locusticola* produces white colonies and ellipsoid to oblong-ellipsoid or fusiform conidia. Some interesting bioassay tests also show that *P. reniformis* isolated from grasshoppers in Indonesia did not infect lepidopteran larvae at the concentrations tested and the exposure method used, although the species did infect long- and short-horned tettigoniid grasshoppers, suggesting that *P. reniformis* may be specific to this insect group (Kalkar et al. 2006).

Paecilomyces atrovirens differs from *I. locusticola* by its dark green colony, long cylindrical conidia (4.2–7.2 µm), phialides with a lecythiform basal portion and imbricate conidial chain (Liang et al. 1991). *I. locusticola* and *I. javanica* have similar conidiogenous structures , but the conidia of the former are ellipsoid,(1.2–2 × 2.4–4.2 µm), fusiform to oblong- ellipsoid (3.5–4.5 × 1.2–1.5 µm), while they are cylindric (5–7.4 × 1.5–1.7 µm) in the latter (Samson

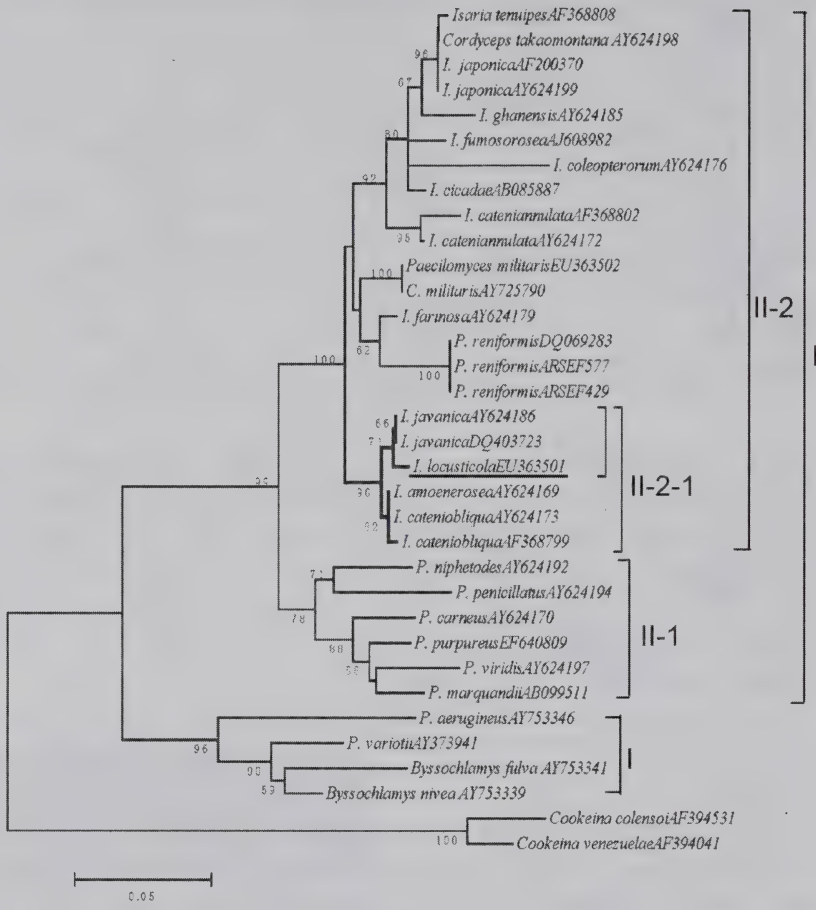
Isaria tenuipesAF368808
Cordyceps takaomontana AY624198
I. japonicaAF200370
I. japonicaAY624199
I. ghanensisAY624185
I. fumosoroseaAJ608982
I. coleopterorumAY624176
I. cicadaeAB085887
I. cateniannulataAF368802
I. cateniannulataAY624172
Paecilomyces militarisEU363502
C. militarisAY725790
I. farinosaAY624179
P. reniformisDQ069283
P. reniformisARSEF577
P. reniformisARSEF429
I. javanicaAY624186
I. javanicaDQ403723
I. locusticolaEU363501
I. amoeneroseaAY624169
I. cateniobliquaAY624173
I. cateniobliquaAF368799
P. niphetodesAY624192
P. penicillatusAY624194
P. carneusAY624170
P. purpureusEF640809
P. viridisAY624197
P. marquandiiAB099511
P. aerugineusAY753346
P. variotiiAY373941
Byssochlamys fulva AY753341
Byssochlamys nivea AY753339
Cookeina colensoiAF394531
Cookeina venezuelaeAF394041
96
67
80
92
95
100
62
100
100
66
71
96
92
99
71
78
88
58
96
90
59
100
II-2
II
II-2-1
II-1
I
0.05

Fig. 2 Phylogenetic tree based on analysis of rDNA ITS1–5.8S–ITS2 sequences of *I. locusticola* and some related species.

1974). A morphological comparison of *I. locusticola* and related species is shown in Table 2.

Molecular identification

A BLAST search through GenBank was performed by using the ITS sequence of *I. locusticola* as the query. Close matches showing maximal sequence identities of 92–98% included *I. javanica, I. fumosorosea, I. cateniannulata, I. cateniobliqua, I. amoenerosea,* and *I. farinosa.* The ITS sequences of these species and other related species of *Paecilomyces* and other entomogenous fungi were retrieved from GenBank for phylogenetic analysis.

Relationships of *I. locusticola* and related species in *Isaria* and *Paecilomyces* were showed in the phylogenetic tree based on analysis of rDNA ITS1- 5.8S - ITS2 sequences (Fig. 2). *Cookeina colensoi* and *C. venezuelae* were designated as outgroups.

Luangsa-ard et al. (2004, 2005) demonstrated that *Paecilomyces* is polyphyletic, with species falling in two subclasses, *Sordariomycetidae* and *Eurotimycetidae*. Two clades (Clades I and II) were recognized in the phylogenetic tree. Clade I consisted of the thermophilic *Byssochlamys fulva*, *B. nivea*, *P. aerugineus* and *P. variotii* in the *Eurotiales* (*Eurotimycetidae*). Clade II consisted of *Paecilomyces* spp. (*Hypocreaceae, Hypocreales*, *Eurotimycetidae*) and *Isaria* spp. (*Clavicipitaceae, Hypocreales*, *Eurotimycetidae,*). *I. locusticola* grouped with *I. javanica* as sister to *I. cateniobliqua* and *I. amoenerosea*. This association was well supported by bootstrap analysis (values = 96%).

Luangsa-ard et al. (2005) did not include *P. reniformis* in their phylogenetic analyses. Our molecular analyses suggest that *P. reniformis* does not group with other *Paecilomyces* species but rather belongs to the entomogenous *Isaria* group, which further suggests that *P. reniformis* belongs to *Isaria*, not *Paecilomyces*. Although both *P. reniformis* and *I. locusticola* parasitize locusts, their separation in the tree support them as independent species.

Both *I. cateniobliqua* and *I. amoenerosea,* which are characterized by red colonies, are in the same subclade but apparently differ from the subclade of *I. locusticola* and *I. javanica*. Although *I. locusticola* and *I. javanica* are closely related by molecular analysis, they produce different conidia and live on different insect hosts. Both the phenotypic description and molecular analyses support recognition of strain GZUIFR-Fj0916 as a new member of *Isaria*.

Acknowledgements

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MYCOTAXON

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Calathella columbiana (*Basidiomycota*): new record of a cyphelloid fungus from Brazil

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Abstract — *Calathella columbiana* is described and illustrated based on material collected in Santa Catarina State, southern Brazil. The species was originally described from Colombia in 1983 and no more recorded from South America, the present record is the second one for the species in this continent.

Key words — *Agaricomycetidae*, *Cyphellaceae* s.l., neotropical fungi

Introduction

Calathella D.A. Reid is a small genus of tubular or cupulate cyphelloid fungi described by Reid (1964). Agerer (1983) studied six *Calathella* species and considered the following characters to distinguish it from other related genera: incrusted surface hairs with rounded tips, suburniform basidia, and oblong-elliptical to cylindrical basidiospores. Currently, eight species are known in the genus (Kirk et al. 2001).

From Brazil, there are few reports on cyphelloid mushrooms (Viégas 1945, Putzke 2002), possibly because of their much reduced size and difficult taxonomy. The genus *Calathella* was only recently reported in Brazil by de Meijer (2001, 2006), who mentioned unidentified specimens growing on *Cyathea* tree-ferns.

In this paper, we report the occurrence of *Calathella columbiana*, the first species reported from Brazil, collected in montane vegetation of Santa Catarina State.

Materials and methods

Specimens were collected and photographed, then macroscopically analyzed following Bodensteiner et al. (2001). Microscopical observations were made from material mounted in 3% KOH and Melzer's reagent. Measurements of the basidiospores do not include the apiculus; the shape was determined based on *Q* (length-width ratio) values according to Largent et al. (1977). Color codes used in the description of the species are those from Maerz & Paul (1930). Specimens are deposited in the herbarium SMDB.

Taxonomy

Calathella columbiana Agerer, Mitt. Bot. Staatssamml. München 19: 192, 1983.

Figs. 1-4

Basidiomes 0.5–0.7 mm diam., scattered to clustered, with a short, stalk-like, attenuated base when young, cupulate, unlobed but some becoming lobed in age, with 2–5 broad finger-like lobes; margins slightly involute; external surface woolly, pale-brown, becoming nearly white at the margin. Hymenium smooth, glabrous, cream-colored. Subiculum lacking. External surface hairs 2–4 μm diam., somewhat twisted, with obtusely rounded tips; tips hyaline, grading into pale yellowish toward the base from intraparietal pigmentation; thickness and color of adjacent trama hyphae similar to those of the bases of external hairs; hairs with irregular incrustation patterns, with alternating densely incrusted and nearly crystal-free areas, and tips sometimes loosely incrusted or entirely glabrous; hairs not swelling in 5 % KOH, dextrinoid. Trama neither agglutinated nor gelatinous; hyphae 2.5–4 μm diam, with walls 0.5 μm thick; outer tramal elements +/- parallel to basidiome surface, frequently septate, yellowish from intraparietal pigmentation; subhymenial hyphae hyaline, short-celled, hardly differentiated from inner tramal hyphae. Clamp connections absent. Basidia 24–27 × 6–7 μm, clavate, 4-spored; sterigmata narrowly horn-like; lacking distinctive transition elements between basidia and surface hairs at basidiome margin. Basidioles (17–) 19–27 (–32) × (3.5–) 5–7.5 μm, clavate. Cystidia absent. Basidiospores 7.5–10 × (–3) 4–5 μm [x = 8.4 ± 0.7 × 4.1 ± 0.6 μm, $Q = 1.7 - 2.7$, $Q_m = 2.4 \pm 0.6$, $n = 20$], asymmetrically oblong-elliptical to cylindrical or slightly allantoid, apiculate, smooth, hyaline, thin-walled, inamyloid, nondextrinoid.

Habitat: scattered to gregarious on the abaxial surface of decayed grass leaves *Poaceae*, in cleared forest.

Studied material: BRAZIL. Santa Catarina State, municipality of Riqueza, Linha Alta Riqueza, (27° 02'01,4"S – 53°20'13,2"W), 340 m alt., 27.XII.2006, leg. *A.A. Spielmann & M.A. Sulzbacher-89* (SMDB 10.988)

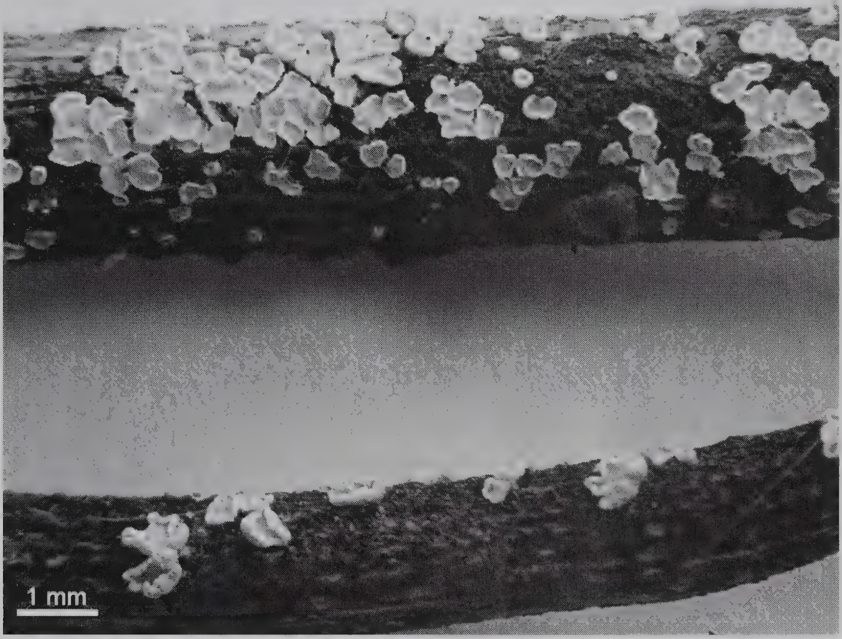

Fig. 1. *Calathella columbiana*. Fresh basidiomes.

Remarks: The studied Brazilian material is similar to *C. digitiformis* Bodenst. et al. (Bodensteiner et al. 2001), another recently described species from Bali, Indonesia. However, the latter species presents a set of features that differ from *C. columbiana*; i.e., digitiform basidiomes 0.7–1.5 mm diam. with numerous finger-like lobes, narrower basidiospores (2.5–3.5 µm diam. with mean width 3 µm; $Q_m = 2.8$) and smaller basidia (14.5–21 × 4.5–6 µm – Bodensteiner et al. 2001). Both species grow on herbaceous substrates.

The Brazilian collection exhibits intermediate characters between the species cited above. For example, the size of the basidiospores and basidia are smaller than those described for *C. columbiana* by Agerer (1983). In addition, a few basidiomes are slightly lobed, but not as dissected as those of *C. digitiformis*. Based on the neotropical distribution and macroscopic features, we consider our specimen within the morphological variation of *C. columbiana*, which is a poorly known species. Prior to this report *C. columbiana* was known only from Colombia (type locality) and its distribution is now extended to southern Brazil.

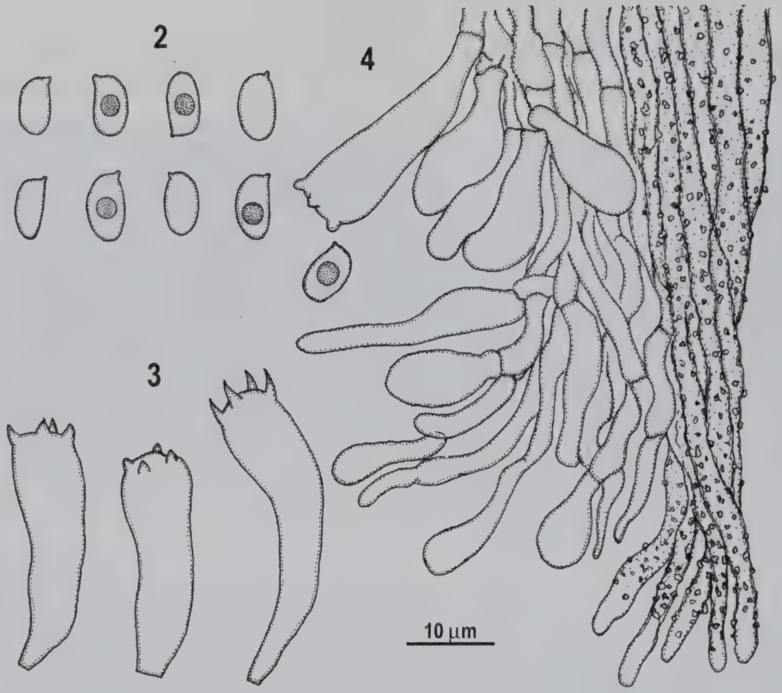

Fig. 2-4. *Calathella columbiana*: 2) Basidiospores. 3) Basidia. 4) Basidiome section.

The taxonomic circumscription and phylogenetic position of the genus *Calathella* is somewhat controversial, and recent molecular studies indicate unresolved phylogenetic relationships suggesting that *Calathella* is not monophyletic. *Calathella columbiana* was segregated from the other *Calathella* species included in the analyses of Bodensteiner et al. 2004. In this work, *C. columbiana* was sister of *Mycenoporella lutea* Overeem, a mycenoid species with a poroid hymenophore and together they were sister of the *Entolomataceae*. In comparison, *C. mangrovei* E.B.G. Jones & Agerer, and *C. gayana* (Lév.) Agerer were distantly related to each other in the *Nia* clade and collectively were sister of the *Omphalotaceae*. It should be noted, however, that the relationships amongst the major clades presented in Bodensteiner et al. (2004) were significantly different from those in the multi-locus analyses of Matheny et al. (2006). Singer (1986) accepted *Calathella* as a synonym of the genus *Flagelloscypha* because both taxa formed cyphelloid basidiomes covered with dextrinoid, thick-walled hairs, and he maintained the distinction from the genus *Lachnella* whose members have inamyloid hairs. In addition Singer (1986) was reluctant to accept the numerous segregate genera recognized by Agerer (1983) that were delimited by subtle micromorphological features. Recent molecular data (Bodensteiner et al. 2004; Binder et al. 2005) support the acceptance of *Calathella, Flagelloscypha* and *Lachnella* as distinct genera, but the relationships amongst them are equivocal, and as already indicated, *Calathella* is polyphyletic. It should be noted that the type species of *Calathella*, *C. eruciformis* (Batsch) D.A. Reid, is not included in any published molecular studies, and accordingly whether its phylogenetic affinities lie with *C. columbiana* or *C. mangrovei* or *C. gayana* cannot be ascertained. Until the generic circumscription of *Calathella* is clarified, we tentatively accept *C. columbiana* in *Calathella*.

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A new species within the *Gymnopus dryophilus* complex (*Agaricomycetes, Basidiomycota*) from Italy

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Abstract — *Gymnopus inexpectatus*, collected from a coastal ecosystem in Italy on a dead branch of *Quercus ilex*, is proposed as a new species. ITS and LSU rDNA sequences place it in the *G. dryophilus* complex within sect. *Levipedes* subsect. *Levipedes*, where its compact coralloid pileipellis structure and broadly ellipsoid spores (Q = 1.5) make it unique. A Latin diagnosis, technical description, illustrations, and taxonomic speculations on *Gymnopus-Marasmiellus* relationships are provided. Comparisons with the European, North/South American and Indonesian species that represent the most closely related species are also presented.

Key words — *Collybia*, gymnopoid/omphalotoid clade, Mediterranean *Agaricales*, *Omphalotaceae*, taxonomy

Introduction

The genus *Gymnopus* (Pers.) Roussel (*Agaricomycetes*, *Agaricales*, *Omphalotaceae*) includes saprotrophic (mainly litter decay) non-mycotrophic agarics (Antonín & Noordeloos 1997, 2008) with white to cream-coloured spore-prints, stipes that are not insititious but usually with basal mycelium and/or rhizomorphs, rooting or rarely originating from a sclerotium, a cutis type pileipellis composed of narrow, cylindrical hyphae or a complex structure of inflated terminal elements (*dryophila*–structure), inamyloid, non-dextrinoid, acyanophilic basidiospores, and non-dextrinoid contextual hyphae. *Gymnopus* is a character-poor genus, since many taxa diverge in only very subtle features, such as basidiomata macromorphology, pileipellis structure, cystidia shape and basidiospore size. This complicates species identification, often daunting from a morphological perspective.

While studying mycobiota of the Natural Park of Rimigliano (S. Vincenzo, Livorno, Tuscany, Italy), 120 hectares of sandy coastal ecosystem formed by holm oak (*Quercus ilex* L.) and cork oak (*Q. suber* L.) woods and by a dense mediterranean pine forest (*Pinus pinea* L., *P. pinaster* Aiton), specimens of an unusual *Gymnopus* species have been found. After comparison with species from Europe, (e.g. Vilgalys & Miller 1987a, Noordeloos 1995, Bon 1999, Antonín & Noordeloos 1997, 2008), North and South America (e.g. Vilgalys & Miller 1983, Halling 1983, 1996, 1997; Mata et al. 2006) and Asia (Indonesia, Wilson et al. 2004), it is considered to represent a new species. It is described and illustrated below.

Materials and methods

Macro- and micromorphology

Macroscopic characters were examined from fresh material. Microscopical studies are based on dried material using a Leica DM 4500 B and an Olympus BX50 light microscope with magnifications up to 1000 x. Observations were made on mounts in the following reagents: Congo Red in 10% ammonia, Cresyl-Blue in water, Melzer's reagent and 3% KOH. Measurements are based on observation of 30 basidiospores of two basidiomata (apiculus not included). The following abbreviations have been used: E = the quotient of length and width of the spores; Q = the mean value of E values in all collections studied; L = number of entire lamellae; l = number of lamellulae between each pair of entire lamellae. All examined material has been deposited and preserved in MCVE (Museo Civico di Storia Naturale, Venice, Italy). Herbarium abbreviations follow Holmgren & Holmgren (1998). Latin description of the new species has been deposited in MycoBank.

DNA amplification and sequencing

The DNA from a dried basidiome was extracted using the DNA Plant Minikit (Qiagen) and following manufactor's instructions. The partial internal transcribed rDNA spacer (ITS) and the D2 region of the large subunit (LSU) rDNA were amplified through the polymerase chain reaction (PCR). The primer pairs ITS1F/ITS4 for ITS (White et al. 1990, Gardes & Bruns 1993) and 0061/NDL22 for LSU (van Tuinen et al. 1998, Kjøller & Rosendahl 2000) were used both for PCR reactions and sequencing. The PCR products were purified by the PCR purification kit and sequenced by DiNAMYCODE S.r.l. Searches for similar sequences allowing taxonomic identification were conducted using the BLASTN algorithm available through the NCBI (http://www.ncbi.nlm.nih.gov/blast/Blast.cgi). The two consensus sequences have been deposited in GenBank and the relative accession numbers are listed with the collection.

Taxonomy

Gymnopus inexpectatus Consiglio, Vizzini, Antonín & Contu, **sp. nov.** FIGURES 1,2
MycoBank MB 511701

Pileus 25-30 mm latus, convexus vel plano-convexus, hygrophanus, ochraceo-brunneus, maculis ferruginosis designatus, laevis, glaber. Lamellae (sub)distantes, L = 25-30, l = 2-6 (7), adnatae, cremeo-roseae. Stipes longus tam quam pilei diametron vel vix longior, 5-6 mm crassus, cylindraceus, insiticius, concolor cum pileo, longitudinaliter fibrillosus, basi tomentosus. Caro cartilaginea. Odor nullus. Sapor mitis. Sporae 5–6 (7.0) × 3.2–4 (4.5) µm, E = 1.4–1.7, (late) ellipsoideae, ovoideae, tenuitunicatae, hyalinae, laeves, inamyloideae. Basidia tetraspora, clavata. Cheilocystidia 27–45 × 5–8 µm, lageniformia, subfusoidea vel subcylindracea, saepe rostrata, saepe irregularia vel subcoralloidea. Lamellarum trama ex cylindraceis vel fusoideis hyphis constituta. Pileipellis ex singulari specie "dryophila-structurae" efformata, ex versiformibus, cylindraceis, clavatis, fusoideis vel utriformibus, hyalinis vel pigmento parietali luteolo-brunneolo hyphis cum digitiformibus propagationibus, constituta. Caulocystidia discretis cystidiis vel (plerumque) terminalibus cellulis similia. Fibulae adsunt ubique.

***Holotypus** in loco Rimigliano dicto prope S. Vincenzo (Livorno, Italy), 2.XII.2006 lectus, leg. G. Consiglio, E. Franceschini et G. Perdisa, in Herbario MCVE sub n° 16126 conservatur.*

ETYMOLOGY: from *inexpectàtus* (Latin), meaning "unexpected, unforeseen".

PILEUS 25–30 mm, convex to plano-convex, applanate with age, with slightly involute margin, hygrophanous, not translucently striate when moist, brownish ochre, rusty red spotted, pallescent to ochraceous cream, smooth, glabrous, slightly tomentose at margin. LAMELLAE rather distant, subdistant, L = 25–30, l = 2–6 (7), adnate, rosy cream, with entire to hardly uneven, concolorous edge. STIPE of the same length, or slightly longer, than pileus diameter, 5–6 mm thick, cylindrical, slightly broadened at base, insititious, stuffed, concolorous with the pileus, longitudinally fibrillose, tomentose at base, without rhizomorphs. CONTEXT cartilaginous, concolorous with the external surfaces. SMELL none, indistinct. TASTE mild.

BASIDIOSPORES 5–6 (7) × 3.2–4 (4.5) µm, on average 5.9 × 3.8 µm, E = 1.4–1.7, Q = 1.5, (broadly) ellipsoid, ovoid, smooth, thin-walled, hyaline, inamyloid (Fig. 2b). BASIDIA 20–25 × 6–7.5 µm, 4-spored, clavate, often subcapitate. BASIDIOLES 14–23 × 3–6 µm, clavate, cylindrical. CHEILOCYSTIDIA 27–45 × 5–8 µm, lageniform, subfusoid or subcylindrical, often rostrate, often irregular to subcoralloid, thin-walled (Fig. 2a). PLEUROCYSTIDIA absent. HYMENOPHORAL TRAMA consisting of cylindrical to fusoid, thin-walled, up to 13 µm wide hyphae. PILEIPELLIS a special form of "*dryophila*-structure", composed of versiform,

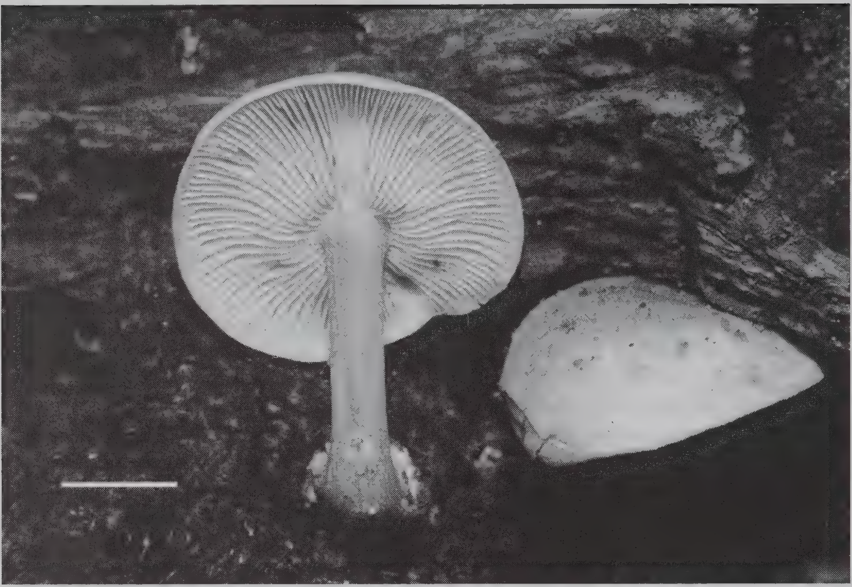

Fig. 1. *Gymnopus inexpectatus* (holotype). Basidiomata. Scale bar = 10 mm.

cylindrical, clavate, fusoid or utriform, ± thin-walled, 30–62 × 8–15 µm elements, which are irregular, coralloid or with ± digitate projections, hyaline to pale yellowish-brownish in KOH (Fig. 2d); with parietal and fine epiparietal-encrusting pigment. STIPITIPELLIS a cutis consisting of cylindrical, parallel, thick-walled (up to 1 µm), smooth, up to 7 µm wide hyphae. CAULOCYSTIDIA in the form of discrete cystidia or (mostly) terminal cells, 17–48 × 4.5–10 µm, adpressed to erect, cylindrical, clavate, regular, irregular to coralloid, ± thin- to thick-walled (Fig. 2c). CLAMP CONNECTIONS present in all tissues. CHEMICAL REACTIONS, no part of the basidiome dextrinoid or amyloid and not staining green in KOH.

HABITAT. On a little branch of *Quercus ilex* fallen on the soil.

COLLECTION EXAMINED — Italy, S. Vincenzo, Livorno, in the *Quercus ilex* forest of Rimigliano: two basidiomes on a branch of *Q. ilex*, 2nd Dec. 2006, leg. G. Consiglio, E. Franceschini et G. Perdisa (holotype MCVE 16126; GenBank accession numbers EU622905 and EU622906).

Molecular results

The ITS and LSU rDNA D2 regions were amplified from the dried basidiome. The size of the ITS and LSU rDNA fragments was 238 bp and 606 bp, respectively. Searching for similar sequences in GenBank database pointed to taxa within the *Gymnopus dryophilus* complex (Tab. 1).

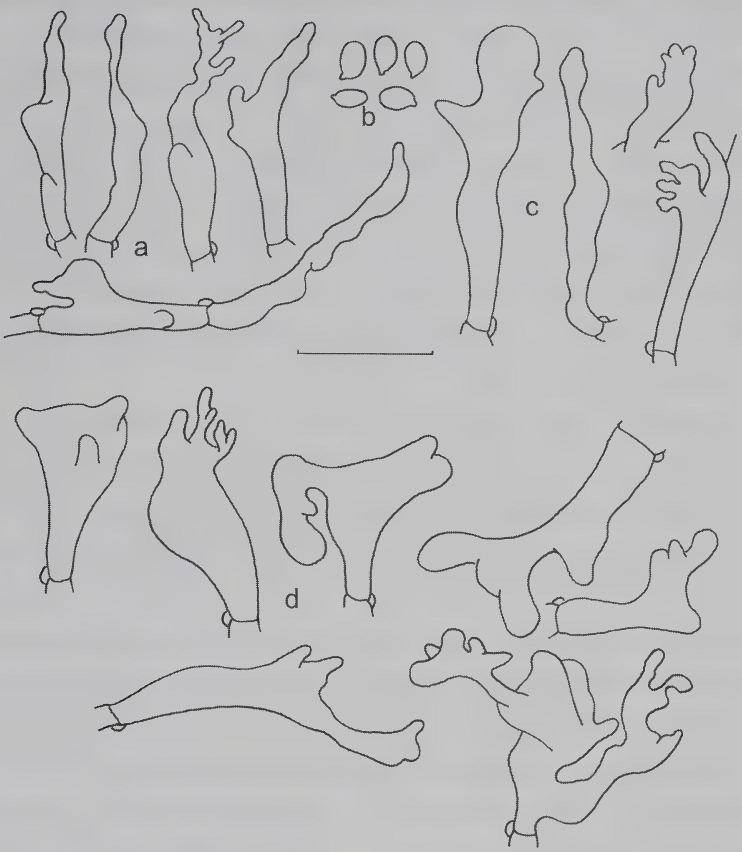

Fig. 2. *Gymnopus inexpectatus*. Micromorphologic characters of the basidiomata. **a.** Cheilocystidia. **b.** Basidiospores. **c.** Caulocystidia. **d.** Pileipellis elements (all from holotype). Scale bar = 20 µm.

Discussion

This new species is well characterised by a unique combination of features. Nevertheless its taxonomic relationships are problematic: our collection combines characters such as a gymnopoid habitus (viz. pileus relatively fleshy, not distinctly striate, lamellae usually not distant, stipe not filiform to hair-like but cartilaginous), that suggest a close relationship with *Gymnopus*, with characters (viz., coralloid pileipellis structure, lignicolous habit, insititious stipe) reminiscent of several *Marasmiellus* s.l. species (Antonín et al. 1997, Antonín & Noordeloos 1993, 1997, 2008). However, recent molecular analyses by Mata et al. (2004, 2006) and Wilson & Desjardin (2005) note that the type species of

Gymnopus (*G. fusipes*), *Micromphale* Gray (*M. foetidum*) and *Setulipes* Antonín (*S. androsaceus*) cluster within the same clade and that *Marasmiellus* Murrill represents an artificial, polyphyletic genus, suggesting that some *Marasmiellus* species should be included with *Setulipes* and *Micromphale* within *Gymnopus.*

Analyses of ITS and LSU rDNA sequences place our fungus in the *Gymnopus dryophilus* complex, a group of species belonging to section *Levipedes* (Fr.) Halling, subsection *Levipedes* (Antonín & Noordeloos 1997) (Tab. 1). This subsection traditionally encompasses species that share the following anatomical features: a pileipellis composed of relatively short, inflated, branched, loosely arranged hyphae, usually not coralloid or diverticulate (forming the so-called *dryophila*-structure, with elements which resemble a jig-saw puzzle, best seen in paradermal scalps); well-differentiated cheilocystidia, and pileipellis hyphae that do not turn green in alkali.

G. dryophilus could be conceived as a complex of morphologically similar species. This complex was clearly distinguished from the rest of the section *Levipedes* by both morphologically based phenetic and cladistic inferences (Vilgalys 1986), and molecular analyses (Wilson et al. 2004, Mata et al. 2006). The presence of mating intersterile groups within this species complex ("biological species") from both North America (Vilgalys & Miller 1983) and Europe (Vilgalys & Miller 1987b) was also supported by DNA/DNA hybridization experiments (Vilgalys 1991). Concurrent morphological studies also demonstrated small morphological differences among species recognized within either continent (Vilgalys & Miller 1983, 1987a). These species and their infraspecific taxa could be distinguished based on a combination of shape and size of cheilocystidia together with rhizomorphs and gill colour.

Wilson et al. (2004) and Mata et al. (2006) are the first to attempt to circumscribe the taxa within this complex using ITS sequences. Both Bayesian and parsimony analyses of sequences within sect. *Levipedes* and the *G. dryophilus* complex show little variation and differ from one another by only 5-10 bp (Mata et al. 2006). Morphological plasticity and lack of resolution of ITS sequence analyses complicate assignment of complex members to morphotaxa. Mata et al. (2006) observe that the *G. dryophilus* complex seemingly has a Euro-American distribution; this may be an artefact resulting from poor specimen sampling.

Within this section and complex, *G. inexpectatus* is well characterized by (1) a stipe with poorly developed basal mycelium, (2) growth on *Quercus ilex* wood debris, (3) a trichoderm-like pileipellis comprising coralloid digitate elements, irregular to subcoralloid cheilocystidia, and (4) broadly ellipsoid spores (Q = 1.5). These results show that sect. *Levipedes* (Fr.) Halling s. Antonín et al. (1997) may also contain species with coralloid pileipellis cells as an extreme case of *dryophila*-structure.

Table 1. Similarities of *G. inexpectatus* ITS and LSU rDNA sequences to those retrieved from the GenBank database.[1]

Accession #	Descriptions	Identity (%)	E*Value
	ITS		
DQ480098	*Gymnopus dryophilus* voucher Duke	99	7e-114
DQ480097	*Gymnopus dryophilus* Duke 242	99	7e-114
DQ449960	*Gymnopus ocior* voucher TFB4284	99	7e-114
DQ449959	*Gymnopus ocior* voucher TFB9015	99	7e-114
DQ449957	*Gymnopus ocior* voucher TFB3861	99	7e-114
	LSU (=28S)		
AF042595	*Collybia dryophila* isolate RV83/180	99	0.0
AY640619	*Gymnopus dryophilus* isolate AFTOL-ID 559	99	0.0
AF291305	*Gymnopus dryophilus* 28S large subunit rDNA, partial sequence	99	0.0
AY639411	*Gymnopus bicolor* voucher AWW116-SFSU	97	0.0
AF261328	*Micromphale foetidum* strain JEJ.VA.567	97	0.0

[1] Search method: algorithm BLASTN 2.2.17 (Jun. 24, 2007) available at the NCBI site (http://www.ncbi.nlm.nih.gov/BLAST/), performed on Febr. 8, 2008.

(*) The expected E value represents the estimated number of sequences randomly corresponding (the lower the value, the better the correspondence with the sequence in the database).

None of the *Gymnopus* monographs from Europe (Antonín & Noordeloos 1997, 2008; Bon 1999), the Americas (Vilgalys & Miller 1983, Halling 1983, 1996, 1997; Mata et al. 2006), or Asia (Wilson et al. 2004) include a taxon close to the new species proposed here. The most closely related described species seems to be *G. dryophilus* var. *lanipes* (Malençon & Bertault) A. Ortega et al. (Malençon & Bertault 1975, Lonati 1986, Bon 1999, Vila & Llimona 2002, Ortega et al. 2003, Antonín & Noordeloos 2008), which exhibits similar habit and microscopical features. However, it differs from *G. inexpectatus* by having a non-insititious stipe, long stipe hairs, a more distinctly "jigsaw" (*dryophila*-like) pileipellis structure, and different spore size (E = 1.6–2.3, Q =1.85; Ortega et al. 2003). *G. dryophilus* var. *lanipes* typically grows in Mediterranean thermophilous forests (Morocco, Italy and Spain) among vegetal debris (such as *Quercus ilex*, *Pinus* spp., or, more rarely, *Cistus* spp). Ortega et al. (2003), who studied the holotype (nº 4508) in Malençon's Montpellier herbarium (MPU), notes that the holotype material does not correspond to the taxon described in the protologue. It has a pubescent stipe, but its spores are larger (9–11 × 4–5 μm), the pileipellis is a cutis of typical filamentous hyphae without a *dryophila*-structure, and the basidiomata are brown-reddish: this collection may represent a taxon within the *G. terginus* group. Because Malençon knew *G. terginus* very well, Ortega et al. (2003) supposed that a designation of the material as holotype was surely an unintentional error and selected a neotype from Iberian material that fitted the original description in all aspects, keeping the original name.

One recently described Spanish species, *G. bisporus* (J. Carbó & Pérez-De-Greg.) J. Carbó & Pérez-De-Greg. [= *G. catalonicus* (Vila & Llimona) Vila & Llimona 2006, fide Antonín & Noordeloos 2008)], differs from *G. inexpectatus* in having clavate cheilocystidia, mono- and bisporic basidia and spores (8)8.9–10.6(12) × (3.5)4–4.9(5.5) µm in size (Pérez-De-Gregorio & Carbó 2002, Antonín & Noordeloos 2008).

Based only on macro- and micromorphological features, *G. inexpectatus* could be mistaken for a *Marasmiellus*, as interpreted by Antonín & Noordeloos (1993), of sect. *Dealbati* Singer, subsect. *Quercini* Singer (with coloured pileus; Singer 1973, Desjardin 1997). In Europe (Antonín & Noordeloos 2008), the species belonging to the *M. carneopallidus/M. mesosporus/M. maas-geesterani/ M. maritimus* group may look like *G. inexpectatus. M. carneopallidus* (Pouzar) Singer, which has similar pileipellis structure and caulocystidia, can be distinguished by larger spores (7.5–12.5 × 4.5–6.5 µm) and broadly clavate simple cheilocystidia. *M. mesosporus* Singer, with similar cheilo- and caulocystidia, has larger spores (10.5–14.5 × 5–7.5 µm) and larger basidia (25–40 × 8–12 µm) (Takehashi et al. 2007). *M. maas-geesterani* Robich & E. Campo has larger spores [(9)10–12(13.5) × 5–6.5(7.5) µm], differently shaped cheilo- and caulocystidia, and larger basidia (35–45 × 6.5–8.5 µm) (Robich & Campo 2000). *M. maritimus* Contu & Noordel (Noordeloos & Antonín 2008 = *Marasmiellus roseotinctus* Contu & Noordel., nom. illeg., non Pegler) has larger spores (10–14.5 × 4–6 µm) and larger basidia (22–35 × 7–10.5 µm) (Noordeloos & Contu 2007).

In comparison with similar South-American species described by Singer (1973), *M. xerophyticus* Singer has a smaller, 7–13 mm broad, brown pileus with whitish margin, larger spores [(8)9–11 × (4.2)5–6(7) µm], larger basidia (19–36 × 6–7.5 µm), and differently shaped cheilocystidia; *M. aurantiorufescens* Singer has an ochraceous pileus that dries to rufous, longer and narrower spores [(4.5)5.5–6.7 × 2.5–2.8 µm], differently shaped cheilocystidia, and growth on oak leaves; *M. dryogeton* Singer has a smaller (5–11 mm) ochraceous brown to cinnamon brown pileus, larger spores (6.2–8.5 × 3–3.5 µm), smaller cheilocystidia (17–20 × 2–8 µm), different caulocystidia, and grows on oak leaves; *M. enodis* Singer has a brown to deep brown, radially sulcate pileus, larger spores [6.5–9 × 2.5–4(4.5) µm], differently shaped and smaller (22–35 × 7–9.5 µm) cheilocystidia and caulocystidia in the form of *Crinipellis*-like hairs, and grows on dicotyledonous wood; *M. dendroegrus* Singer has an ochraceous-cinnamon, sulcate and striped pileus, larger spores (6–8.5 × 2.8–4.5 µm), differently shaped cheilocystidia and grows on dead wood of dicotyledons; *M. quercinus* Singer has a chestnut to deep cinnamon, small (6–10 mm) pileus, differently shaped, single, ventricose to fusoid cheilocystidia, different stipe covering, and grows on leaves (less frequently on small sticks and acorns) of

Quercus spp. The four last mentioned species are further distinguished by a distinctly dark brown incrusted hypodermium.

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Phellinus mori sp. nov. (*Basidiomycota, Hymenochaetales*) from northern China

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Abstract — A new resupinate member of the *Hymenochaetaceae*, *Phellinus mori*, is described from northern China. It belongs to the *Phellinus laevigatus* complex, but differs by strongly cracked basidiocarps when mature or dry, subparallel skeletals along the tubes, presence of cystidioles, ovoid or subglobose basidiospores, and habitat on *Morus* exclusively.

Key words — lignicolous fungi, poroid fungi, polypore, taxonomy

Introduction

During an investigation on lignicolous and poroid fungi in China, several specimens were collected on *Morus* from Heilongjiang Province and Beijing area in northern China. These collections are macroscopically similar to *Fomitiporia punctata* (P. Karst.) Murrill by resupinate and cushion-shaped basidiocarps, but they become strongly cracked when mature or dry. White mycelial strands are common in old tubes. Microscopically there are many hymenial setae and hyaline, fairly thick-walled, nondextrinoid and moderately cyanophilous basidiospores. The collections belong to the *Phellinus laevigatus* complex but differ sufficiently from all previously described taxa to be described as a new species.

Materials and methods

The studied specimens are deposited at the Herbarium of Beijing Forestry University (BJFC) and the Herbarium of Institute of Applied Ecology, Chinese Academy of Sciences (IFP). The microscopic procedure follows Dai (1999). Sections were studied at magnification up to ×1000 by using a Nikon Eclipse E600 microscope and phase contrast illumination. Drawings were made with the aid of a drawing tube. In presenting the variation in the size of the spores, 5% of measurements were excluded from each end of the range, and are given in parentheses. In the text the following abbreviations are used: IKI = Melzer's reagent, IKI– = negative in Melzer's reagent, KOH = 5% potassium hydroxide, CB = Cotton Blue, CB+ = cyanophilous, CB– = acyanophilous, L = mean spore length (arithmetic average of all spores), W = mean spore width (arithmetic average of all spores), Q = variation in the L/W ratios between the specimens studied, n = number of spores measured from given number of specimens. Special colour terms followed Petersen (1996) and Anonymous (1969).

Description

Phellinus mori Y.C. Dai & B.K. Cui, **sp. nov.** **Figs.1-3**

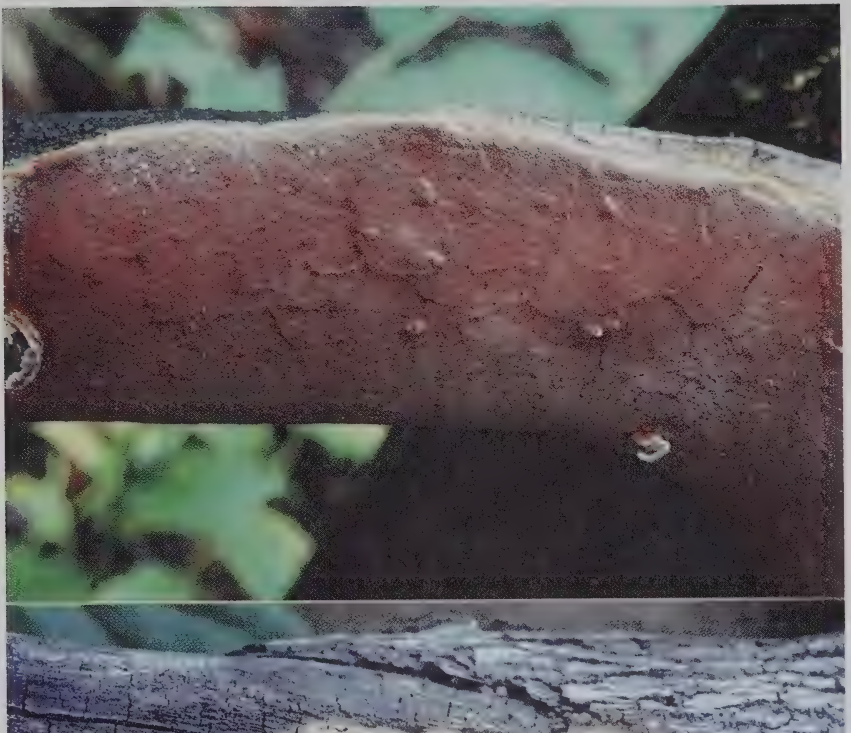
MycoBank MB 511704)

Carpophorum perenne, resupinatum. Facies pororum cinnamomeum vel brunneum, pori rotundi, 7–8 per mm. Systema hypharum dimiticum, hyphae generatoriae septatae sine fibulis, hyphae skeletales contextum 2–4 µm in diam. Setae sdsunt in hymenio, 11.6–26 × 5–8.4 µm. Sporae ovoideae vel subglobosae, pallidae, crassitunicatae, 4.5–5.2 × 3.8–4.6 µm.

Type. — **China.** Heilongjiang Prov., Ning'an County, Jingbohu Nature Reserve, on living tree of *Morus*, 8.IX.2007 *Dai 8363* (**holotype** in IFP, isotypes in BJFC & H).

Etymology — *mori* (Lat.): referring to the host tree genus.

Fruitbody — Basidiocarps perennial, resupinate, firmly attached to the substrate, not readily separable, without odour or taste when fresh, woody hard and medium in weight when dry, up to 15 cm long and 6 cm wide, and 1 cm thick, usually receding and becoming cushion-shaped with age. Pore surface cinnamon brownish when fresh, becoming dark brown when bruised, clay buff and strongly cracked when mature or dry, with a slightly silky sheen; sterile margin narrow to almost lacking, concolorous with pores; pores mostly circular, some slightly sinuous, (6–)7–8(–10) per mm (n=90/3); dissepiments thin, entire. Context present at each layer, cinnamon brown to fawn brown, hard corky, ca. 0.1 mm thick. Tubes concolorous with pores, woody hard; white mycelial strands usually present in old tubes; tube layers distinct.



Figs. 1–2. *Phellinus mori.* Fig. 1. Fresh basidiocarp. Fig. 2. Dried basidiocarp.

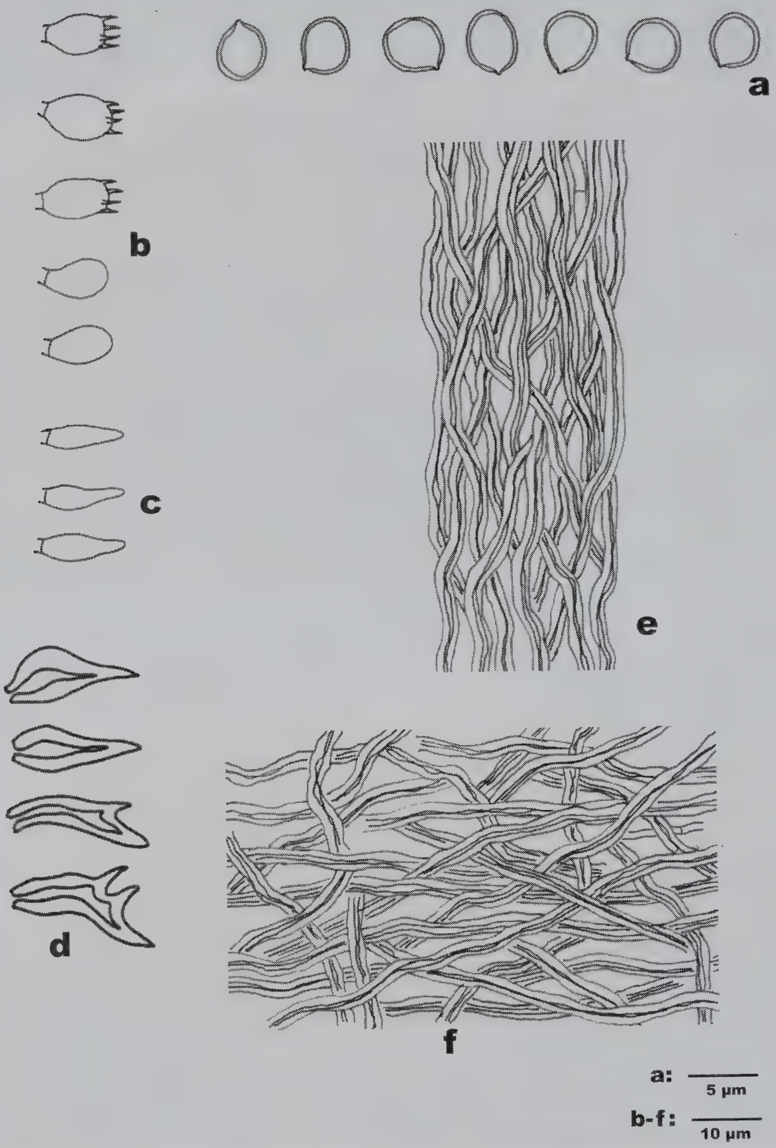


Fig. 3. Microscopic structures of *Phellinus mori* (drawn from the holotype). —a: Basidiospores. —b: Basidia and basidioles. —c: Cystidioles. —d: Setae. —e: Hyphae from trama. —f: Hyphae from context.

HYPHAL STRUCTURE — Hyphal system dimitic; all septa without clamp connections; tissue darkening but otherwise unchanged in KOH.

CONTEXT — Generative hyphae hyaline to pale yellowish, thin-walled, frequently branched and simple septate, 2–3.2 µm in diam; skeletal hyphae dominant, rust brown, thick-walled with a narrow lumen to subsolid, unbranched, rarely septate, flexuous, interwoven, 2.5–4 µm in diam; hyphae of white mycelial tufts, hyaline, thin-walled, strongly branched and flexuous, 1–1.8 µm in diam.

TUBES — Generative hyphae hyaline, thin-walled, occasionally branched, frequently septate, 1.5–2.5 µm in diam; skeletal hyphae dominant, rust brown, thick-walled with a narrow lumen to subsolid, more or less straight to flexuous, subparallel along the tubes, 2.2–3.5 µm in diam. Setae frequent, ventricose to subulate, some furcate, dark brown, thick-walled, 11–24 × 5–8.5 µm; fusoid cystidioles occasionally present, 8.7–14.7 × 3.4–5.2 µm; basidia barrel-shaped, with four sterigmata and a simple septum at the base, 9–13.2 × 5.3–8 µm; basidioles in shape similar to basidia, but slightly smaller; secondary hyphae of mycelial strands hyaline, thin-walled, frequently branched and septate, 1.5–2 µm in diam. Rhomboid crystals frequently present in trama and hymenium.

SPORES — Basidiospores mostly ovoid, sometimes subglobose, hyaline, fairly thick-walled, smooth, IKI–, moderately CB+, (4–)4.3–5.2(–5.4) × (3.5–)3.8–4.6(–4.8) µm, L=4.74 µm, W=4.16 µm, Q=1.11–1.31 (n=210/7).

ADDITIONAL SPECIMENS (PARATYPES) EXAMINED. — **China.** Beijing, Daxing County, Gusangyuan, dead branch of living *Morus*, 4.IX.2007 *Dai 8291, 8292, 8293, 8294, 8295, 8297, 8298, 8300, 8301, 8303* & *8305* (IFP & BJFC). Heilongjiang Prov., Ning'an County, Jingbohu Nature Reserve, on living tree of *Morus*, 8.IX.2007 *Dai 8309, 8310, 8339, 8342, 8344* & *8353* (IFP & BJFC).

Discussion

Phellinus mori belongs to the *P. laevigatus* complex, which includes *P. betulinus* (Murrill) Parmasto, *P. laevigatus* (P. Karst.) Bourdot & Galzin, *P. prunicola* (Murrill) Gilb., *P. rhamni* (Bondartseva) H. Jahn, and *P. spiculosus* (W.A. Campb. & R.W. Davidson) Niemelä. Parmasto (2007) studied the complex and provided statistical analyses of the basidiospores.

Phellinus mori resembles *P. laevigatus* s. str., but basidiospore shapes differ in the two species: ovoid or subglobose in *P. mori*, while ellipsoid in *P. laevigatus* s. str. In addition, basidiospores of *P. laevigatus* s. str. (4.56–5.46 × 3.58–4.15 µm, L=5.01 µm, W= 3.87 µm, Q=1.21–1.39, Parmasto 2007) are narrower than those in *P. mori*. Macroscopically, the basidiocarp of *Phellinus mori* is strongly cracked when mature or dry, while it is not cracked in *P. laevigatus* s. str.

According to Parmasto (2007) *Phellinus laevigatus* occurs in Europe, West Siberia and Middle Asia, and its hosts are exclusively trees of *Betula*. *Phellinus* *mori* was found in Beijing and Heilongjiang in northern China, growing exclusively on dead branches and living trees of *Morus*.

Phellinus mori is morphologically similar to *P. betulinus*, and the latter species occurs in China (treated as *P.* cf. *laevigatus*, Dai 1999). But *P. betulinus* has distinctly smaller basidiospores (3.25–4.55 × 2.51–3.49 µm, Parmasto 2007), and it has been found so far only on *Betula*.

Among the members of the *Phellinus laevigatus* complex, basidiospores of *P. prunicola*, *P. rhamni* and *P. spiculosus* are 5.21–6.43 × 3.86–4.63 µm, 5.46–5.78 × 4.22–4.82 µm and 4.99–6.1 × 3.83–5.23 µm respectively (Parmasto 2007), and *P. mori* differs from these species by smaller basidiospores. Basidiospores of *Phellinus spiculosus* and *P. mori* may be slightly overlapped, but the former has basidiocarps not cracked and lacks cystidioles. Ecologically *Phellinus spiculosus* causes cankers on *Quercus* and *Carya* (Gilbertson and Ryvarden1987), but *P. mori* does not cause cankers, and lives on *Morus* exclusively.

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Perenniporia minor (*Basidiomycota*, *Polyporales*), a new polypore from China

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Abstract — A new polypore, *Perenniporia minor*, collected from Changbaishan Nature Reserve, northeastern China, is described and illustrated. It is a saprophyte growing on fallen angiosperm branches. Macroscopically it differs from other species in the genus by tiny and pileate basidiocarps. Unlike most species of the genus, *P. minor* is characterized microscopically by almost negative skeletal hyphae in Melzer's reagent. *P. minor* and *P. truncatospora* have more or less similar basidiospores, but the latter has smaller pores, and its basidiospores are nondextrinoid.

Key words — lignicolous and poroid fungi, *Polyporaceae*, taxonomy

Introduction

Perenniporia Murrill is a cosmopolitan genus with around 90 species described and accepted (Gilbertson & Ryvarden 1987, Ryvarden & Gilbertson 1994, Hattori & Lee 1999, Decock & Figueroa 2000, Decock 2001a, b; Decock et al. 2000, 2001; Núñez & Ryvarden 2001, Dai et al. 2002, Decock & Ryvarden1999a, b, 2000, 2003a, b). Twenty-three species in the genus have been recorded from China (Dai et al. 2002, Cui et al. 2006, 2007), and most of them occur in the tropics or subtropics. During an investigation on wood-inhabiting fungi in northeastern China, a tiny polypore was found that after microscopical examination turned out to represent an undescribed species of *Perenniporia*.

Materials and methods

The studied specimens are deposited at the Herbarium of Institute of Applied Ecology, Chinese Academy of Sciences (IFP). Anatomy was studied, and measurements and drawings were made from slide preparations stained with Cotton Blue. Drawings were made with the aid of a drawing tube. The microscopic routine used in the study followed Yuan et al. (2006). In presenting the variation in the size of the spores, the 5% of the measurements at each end of the range are shown in parentheses. The following abbreviations are used: IKI = Melzer's reagent, IKI– = negative in Melzer's reagent, KOH = 5% potassium hydroxide, CB = Cotton Blue, CB+ = cyanophilous, CB– = acyanophilous, L = mean spore length (arithmetic average of all spores), W = mean spore width (arithmetic average of all spores), Q = variation in the L/W ratios between the specimens studied, n = number of spores measured from given number of specimens. Special colour terms are from Petersen (1996).

Description

Perenniporia minor Y.C. Dai & H.X. Xiong, **sp. nov.** **Fig.1**

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Carpophorum annuum, solitarium, pileatum; facies pororum cremea, pori rotundi, 4–6 per mm. Systema hypharum dimiticum vel trimiticum, hyphae generatoriae fibulatae, hyphae skeletales contextum 2.7–5 µm in diam. Sporae pallidae, ellipsoideae vel truncatae, crassitunicatae, dextrinoidae, CB+, 4.9–6.2 × 3.8–4.5 µm.

TYPE. — **China.** Jilin Prov., Antu County, Changbaishan Nature Reserve, Huangsongpu, alt. 1100 m, on fallen branch of *Acer*, 14.IX.2007 *Dai 9198* (**holotype** in IFP, isotype in BJFC).

ETYMOLOGY — *minor* (L.), referring to the tiny basidiocarp.

FRUITBODY — Basidiocarps annual, pileate, solitary, soft corky, without odour or taste when fresh. Pileus semicircular to spathulate, projecting up to 0.8 cm, 1 cm wide, and 0.3 cm thick. Pileal surface cream to very pale buff when fresh, smooth, indistinctly concentrically zonate, becoming cinnamon-buff to pale brick, distinctly concentrically zonate or sulcate when dry. Pore surface cream when fresh, becoming cinnamon-buff when dry; pores round, 4–6 per mm, tube mouths fairly thick, entire. Context white when fresh, becoming cream and corky when dry, up to 0.1 cm thick; with a very thin cuticle present at the

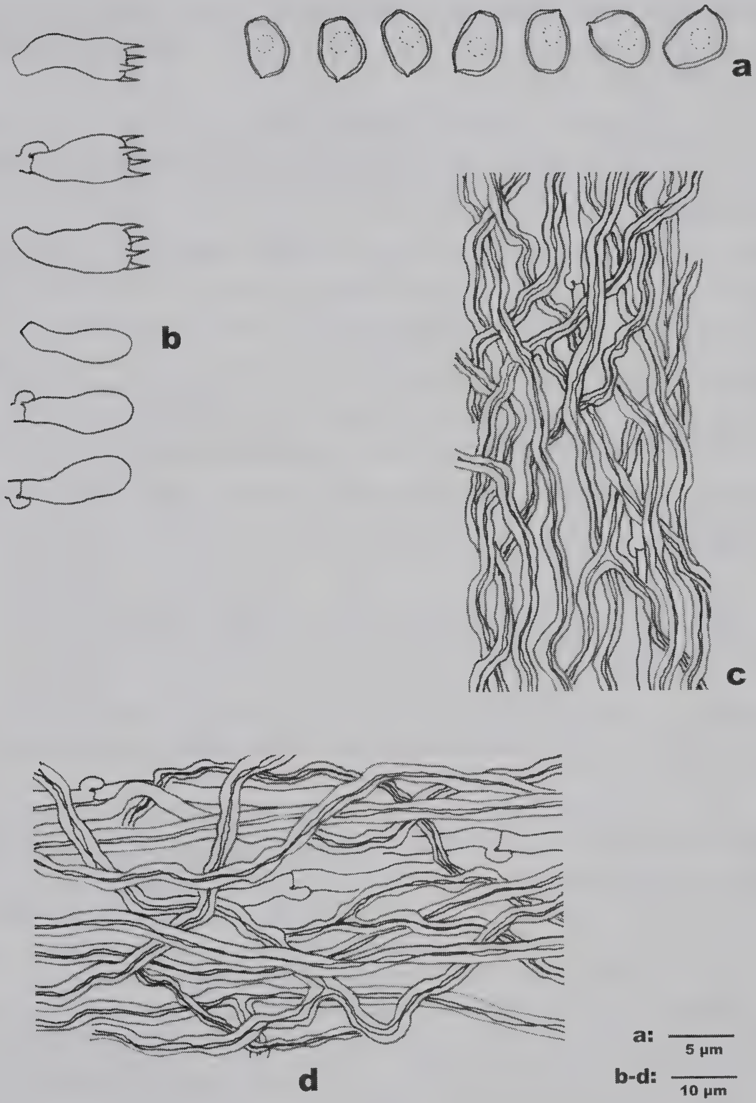

Fig. 1. Microscopic structures of *Perenniporia minor* (drawn from the holotype).
—a: Basidiospores. —b: Basidia and basidioles.
—c: Hyphae from trama. —d: Hyphae from context.

upper surface, cinnamon-buff. Tubes concolorous with pore surface, darker in contrast with context, hard corky, up to 0.2 cm long.

Hyphal structure — Hyphal system dimitic to trimitic; generative hyphae with clamp connections; skeletal hyphae IKI–, or very weakly amyloid, CB+; tissue unchanged in KOH.

Context — Generative hyphae infrequent, hyaline, thin-walled, occasionally branched, 2.2–3.5 µm in diam.; skeletal hyphae dominant, hyaline, thick-walled, mostly with a narrow lumen, occasionally branched (trimitic-like), flexuous, interwoven, 2.7–5 µm in diam.

Tubes — Generative hyphae infrequent, hyaline, thin-walled, occasionally branched, 2–3 µm in diam.; skeletal hyphae dominant, hyaline, thick-walled with a narrow lumen, occasionally branched, flexuous, interwoven, 2.5–4.3 µm in diam. Hymenium usually collapsed, basidia usually infrequent, barrel-shaped to pyriform, with four sterigmata and a basal clamp connection, 13–16 × 4.5–6.5 µm; basidioles in shape similar to basidia, but slightly smaller. Rhomboid crystals frequently present in trama and hymenium.

Spores — Basidiospores ellipsoid, mostly truncate, hyaline, thick-walled, smooth, usually bearing a small guttule, dextrinoid, CB+, (4.7–)4.9–6.2(–7) × (3.6–)3.8–4.5(–4.7) µm, L=5.36 µm, W=4.12 µm, Q=1.26–1.35 (n=96/3).

Additional specimens (paratypes) examined. — **China.** Jilin Prov., Antu County, Changbaishan Nature Reserve, Huangsongpu, alt. 1100 m, on fallen angiosperm branch, 29.XI.2007 *Wei 3500* (IFP). Fusong Country, Lushuihe, Hongwei, on fallen angiosperm branch, 28.XI.2007 *Wei 3467* (IFP).

Remarks — In the field *Perenniporia minor* resembles a juvenile *Tyromyces chioneus* (Fr.) P. Karst., but the latter is readily differentiated microscopically by its thin-walled, nondextrinoid basidiospores.

The new species differs from other taxa in the genus by its tiny and pileate basidiocarp (less than 1 cm), and almost negative skeletal hyphae in Melzer's reagent. *Perenniporia contraria* (Berk. & M.A. Curtis) Ryvarden, *P. truncatospora* (Lloyd) Ryvarden, *P. ohiensis* (Berk.) Ryvarden and *P. ochroleuca* (Berk.) Ryvarden also have small basidiocarps when young, but these species are perennial. In addition, *P. contraria* has smaller basidiospores (3.4–4 × 2.5–3.1 µm, Cui et al. 2006), and spores of *P. ohiensis* (12–14 × 7–8.8 µm, Dai et al. 2002) and *P. ochroleuca* (9–12 × 5.5–7.5 µm, Dai et al. 2002) are distinctly bigger than those of *P. minor*. *P. truncatospora* resembles *P. minor* in basidiospore shape and size (5.3–7.5 × 4–5 µm vs. 4.9–6.2 × 3.8–4.5 µm), but the former has smaller pores (6–8 per mm) and basidiospores that are negative in Melzer's reagent.

Unlike most species of *Perenniporia,* skeletal hyphae of *P. minor* are nondextrinoid, but this character is not unique to the species. In fact, several species of *Perenniporia* have non- to faintly dextrinoid skeletal hyphae, e.g., *P. medulla-panis* (Jacq.) Donk and *P. ohiensis*; however, basidiospores of these species are dextrinoid and cyanophilous. We consider the spore Melzer's and Cotton Blue reactions as more important and consider them as key characters for the genus.

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A taxonomic study of Heterodermia (Lecanorales, Ascomycota) in South Korea based on phenotypic and phylogenetic analysis

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Abstract — A study on taxonomy and phylogeny of *Heterodermia* in South Korea is presented for the first time. Phenotypic analysis was based on morphological, anatomical, and chemical characters, and phylogenetic analysis was based on nrDNA ITS sequences. The results suggest that the genus *Heterodermia* is monophyletic. Some characters (e.g. corticate vs. ecorticate lower surface, absence vs. presence of yellow pigments or soredia) are shown to be taxonomically significant within the genus. Of the eighteen species of *Heterodermia* known to occur in South Korea, eleven were confirmed in this study. Brief species diagnoses accompany a key to *Heterodermia* in South Korea, and comparisons with similar taxa are included.

Key words — lichen flora, macrolichen, *Physciaceae*, comprehensive analysis

Introduction

The genus *Heterodermia* belongs to the lichenized ascomycetous family *Physciaceae* Zahlbr. *Heterodermia* is mainly characterized by linear lobes and by spores of the *Pachysporaria-* or the *Polyblastidia*-type (Poelt 1965, Brodo et al. 2001). All species of *Heterodermia* were included in *Anaptychia* Körb. (Kurokawa 1962) until thick-walled spores and the presence of atranorin came to be regarded as useful characters for separating these genera (Poelt 1965, Swinscow & Krog 1976). Despite the many papers on *Heterodermia* (Awasthi 1973, Swinscow & Krog 1976, Wei 1991, Kurokawa 1998, Moberg & Nash 1999, Grube & Arup 2001, Nordin & Mattsson 2001, Kurokawa 1962), almost no studies on the genus were available for South Korea until the recent macrolichen flora by Park (1990) that treated 12 *Heterodermia* species and provided brief

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[#]Xin Li Wei and Heng Luo contributed equally to this work

Table 1. Seventeen *Heterodermia* specimens used for DNA extraction

Coll. #	Species name	Locality, GPS, alt. (m)	Accession #
040340	*H. boryi*	Mt. Chiri, N35°19'07.0" E127°40'42.7", 1580	EU045422
040754	*H. boryi*	Jeju Do, N33°21'32.9" E126°31'54.9", 1920	EU045423
050093	*H. diademata*	Mt. Deogyu, N35°51'24.1" E127°44'53.6",1580	EU045425
050273	*H. diademata*	Mt. Sorak, N38°09'18.1" E128°19'46.1", 880	EU045426
060639	*H. dissecta*	Mt. Chiri, N35°19'01.0" E127°44'30.1", 1160	EU045424
040658	*H. hypochraea*	Jeju Do, N33°24'26.6" E126°29'46.0", 645	EU045427
060232	*H. hypoleuca*	Mt. Chiri, N35°17'35.3" E127°32'50.3",1390	EU045428
050017	*H. hypoleuca*	Mt. Naejang, N35°29'46.1" E126°53'56.7", 600	EU045429
050317	*H. japonica*	Mt. Sorak, N38°09'11.2" E128°26'24.2", 1265	EU045431
060291	*H. japonica*	Mt. Chiri, N35°18'14" E127°34'10.4", 1430	EU045432
060173	*H. microphylla*	Mt. Chiri, N35°17'25.78" E127°31'59.7", 1420	EU045433
060494	*H. microphylla*	Mt.Deogyo, N35°51'10.0" E127°44'56.9", 1568	EU045434
050136	*H. obscurata*	Wando, N34°21'10.3" E126°41'10.9", 535	EU045435
040623	*H. obscurata*	Jeju Do, N33°28'25.5" E126°29'47.7", 145	EU045436
050493	*H. pseudospeciosa*	Mt. Haegsok, N34°41'21.1" E126°40'47.5"	EU045438
040619	*H. subascendens*	Jeju Do, 145, N33°28'25.5" E126°29'47.7"	EU045441
040847	*H. subascendens*	Jeju Do, 370, N33°27'15.4" E126°33'41.1"	EU045442

descriptions of each species and a key to the taxa. However, some ambiguous morphological characters left some taxonomic problems in need of additional research. The most recently published checklist of Korean lichens (Hur et al. 2005), reports twenty *Heterodermia* species from the Korean peninsula. Thus, in the present study, we have tried to clarify the taxonomy of *Heterodermia* in South Korea based on specimens collected during recent nationwide field surveys. In addition, we also evaluate whether *Heterodermia* is monophyletic and discuss the importance of certain morphological and chemical characters in differentiating species.

Materials and methods

Materials — Two hundred and fifty-six specimens from South Korea have been examined and are deposited in the herbarium of the Korean Lichen Research Institute (KoLRI) in Sunchon, Korea. No type specimens were included in this study.

Morphology — The description of the external morphology is based on air-dried material observed under a dissecting microscope. For anatomical descriptions, sections were made with a razor blade under the stereomicroscope, mounted in GAW (glycerol: alcohol: water = 1:1:1), and observed under a light microscope (Olympus BX 50). Illustrations were taken with a digital camera (Nikon Coolpix 4500).

Chemistry — Lichen substances were detected by the color reaction of a spot test (with KOH) and by thin-layer chromatography (with B solvent system) (Culberson 1972, White & James 1985).

Table 2. Sixty-nine phenotypic characters chosen for phenotypic analysis of *Heterodermia*

No.	Character	No.	Character
1	Thallus foliose	36	Yellow pigment present in the lower surface
2	Thallus subfiliform	37	Rhizines marginal
3	Lobes linear	38	Rhizines at lower surface
4	Lobes subdichotomously branched	39	Rhizines marginal and at lower surface
5	Lobes irregularly branched	40	Rhizines black
6	Lobes discrete	41	Rhizines tan
7	Lobes crowded	42	Rhizines white
8	Lobe tips plane	43	Rhizines concolorous to thallus
9	Lobe tips ascending	44	Rhizines simple to squarrosely branched
10	Lobe tips circinate	45	Rhizines simple to subdichotomously branched
11	Lobe tips with pruina	46	Medulla white
12	The pruina of lobe tips round-patch	47	Pycnidia and (or) apothecia not seen
13	The pruina of lobe tips lack definite shape	48	Pycnidia laminal, limited near tips
14	Lobe tips sometimes orange	49	Conidia bacilliform
15	Soredia present	50	Conidia small
16	Soredia marginal	51	Conidia big
17	Soredia laminal	52	Apothecia lecanorine
18	Soredia marginal and laminal	53	Apothecia laminal
19	Soredia at lower surface	54	Apothecia terminal
20	Round-patch soralia	55	Apothecia marginal
21	Labriform soralia	56	Apothecia margin with lobules
22	Capitate soralia	57	The lobules of apothecia margin pruinose
23	Isidia present	58	Disks pruinose
24	Lobules present	59	Eight ascospores per asci
25	Lobules marginal	60	Ascospores brown
26	Lobules marginal and laminal	61	Ascospores 1-septate
27	Lobules tips suberect	62	Upper cortex prosoplectenchymatous
28	Lobules tips with pruina	63	Grayish surface layer present
29	Lobules isidioid	64	Gonidia green
30	Upper surface maculate	65	Lower cortex prosoplectenchymatous
31	Upper surface papillate	66	No substances contained in the thallus
32	Lower surface corticate	67	Atranorin and zeorin present
33	Lower surface white	68	Norstictic acid present
34	Lower surface pale brown	69	Norstictic and salazinic acids present
35	Lower surface arachnoid		

Phenotypic analysis — The phenotypic analysis is based on sixty-nine phenotypic characters including morphological, anatomical, and chemical characters (Table 2). Maximum parsimony analysis was performed using PAUP version 4.0b10 (Swofford, 2002). The reliability of the inferred tree was tested by 1000 bootstrap replications. *Anaptychia palmatula* (Michx.) Vain. was used as outgroup for the analysis.

DNA extraction and nrDNA amplification — Seventeen lichen thalli (Table1) were fractioned with cryo-tissue-crasher (SK200, Tokken, Japan). Total DNA was extracted directly from whole thalli according to Ekman (1999) with DNeasy Plant Mini Kit (QIAGEN, Germany), then purified by PCRquick-spin™ PCR Product Purification Kit (iNtRON Biotechnology, INC.). The nrDNA ITS region (ITS1-5.8S-ITS2) was amplified by PCR. The primers for amplification were: ITS1F (5'-CTTGGTCATTTACAGGAAGTAA-3'; Gardes & Bruns, 1993) and ITS4A (5'-ATTTGAGCTCTTCCCGCTTCA-3'; White el al. 1990). Conditions for PCR amplification and cycle sequencing have been described previously (Arup 2002).

Sequencing and phylogenetic analysis — PCR products were sequenced using ABI 3700 automated DNA Sequencer in NICEM at Seoul National University. The phylogenetic analysis was executed with software Mega3.1 (Kumar et al., 2004). The Kimura 2-parameter model was selected, and gaps were retained initially while being excluded in the pairwise distance estimation. The neighbor joining (NJ) (Saitou & Nei 1987) method was used to construct the phylogenetic tree, reliability of the inferred tree was tested by 1000 bootstrap replications. Some *Anaptychia* species were available as outgroups for the phylogenetic analysis.

Results and discussion

Phenotypic analysis

Phenotypic analysis (Fig.1) showed that all treated taxa of *Heterodermia* form a monophyletic group, obviously separated from the outgroup *Anaptychia palmatula* with 98% bootstrap support. Within *Heterodermia*, two sections (I and II) based on the presence or absence of a lower cortex were indicated, suggesting that the character-pair 'lower surface corticate or ecorticate' is important to distinguish species.

Section I includes two species clusters (I-1 and I-2) according to the presence of soredia and lobules, respectively. These characters are crucial in the taxonomy among species with a lower cortex. In section II, no striking characters were found to correspond to the topology structure except the spot test character of the lower surface (K+, due to the presence of a yellow pigment). Three species with this character — *H. obscurata*, *H. hypochraea*, *H. subascendens* — and one species that sometimes expresses the character — *H. japonica* — clustered in II-1 to some extent, suggesting that the spot test reaction has taxonomic significance among species lacking a lower cortex. No other phenotypical characters were shown to have taxonomic significance in *Heterodermia*.

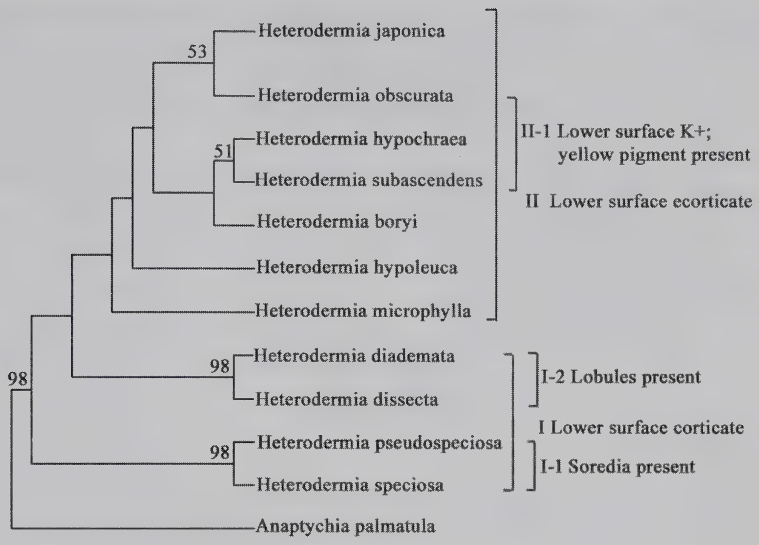
53
51
98
98
98
Heterodermia japonica
Heterodermia obscurata
Heterodermia hypochraea
Heterodermia subascendens
Heterodermia boryi
Heterodermia hypoleuca
Heterodermia microphylla
Heterodermia diademata
Heterodermia dissecta
Heterodermia pseudospeciosa
Heterodermia speciosa
Anaptychia palmatula
II-1 Lower surface K+; yellow pigment present
II Lower surface ecorticate
I-2 Lobules present
I Lower surface corticate
I-1 Soredia present

Fig. 1. Maximum parsimony tree based on morphological, anatomical and chemical characters of 11 species of *Heterodermia* in Korea (*Anaptychia palmatula* = outgroup). Data matrix includes 12 taxa, 69 characters. All characters are of type 'unord', all characters have equal weight, among which 13 characters are constant, 14 variable characters are parsimony-uninformative, number of parsimony-informative characters = 42. Tree length = 138, consistency index (CI) = 0.4058, homoplasy index (HI) = 0.5942, CI excluding uninformative characters = 0.3387, HI excluding uninformative characters = 0.6613, retention index (RI) = 0.4058, rescaled consistency index (RC) = 0.1647. Heuristic search, bootstrap=1000. The numbers in each node represents bootstrap support value, and the numbers lower than 50 were not shown.

Phylogenetic analysis

The NJ consensus tree (Fig.2) clusters all *Heterodermia* species into a well supported (100% support) monophyletic clade that is clearly separated from *Anaptychia* species. Two groups are included within the *Heterodermia* clade, with group I species corticate and group II species ecorticate. This result agrees with those from the phenotypic analysis and confirms that the presence or absence of a cortical layer on the lower surface is an important diagnostic character.

Within the group I, *H. diademata*, *H. pseudospeciosa* and *H. dissecta* are clearly separated. On the one hand, *H. diademata* and *H. dissecta* differ from *H. pseudospeciosa* by the absence or presence of soredia; on the other, *H. diademata* differs from *H. dissecta* by absence or presence of norstictic and salazinic acids, which are also present in *H. pseudospeciosa*. This suggests that absence or presence of soredia or norstictic and salazinic acids are important in separating species in Group I.

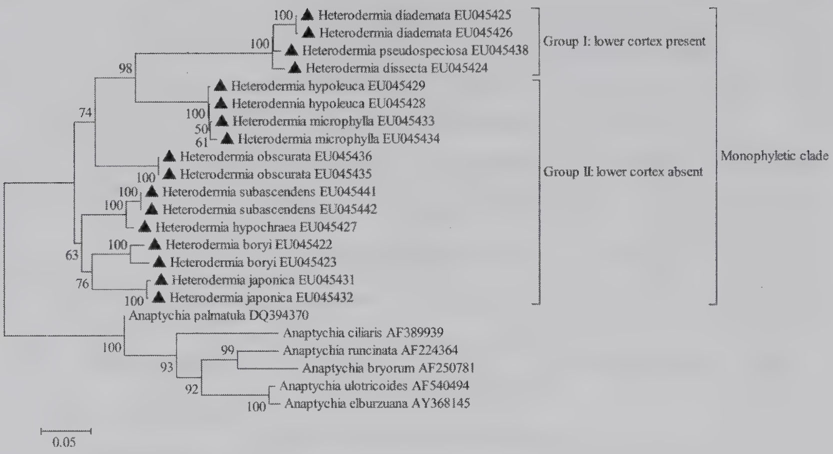
100
▲ Heterodermia diademata EU045425
▲ Heterodermia diademata EU045426
100
▲ Heterodermia pseudospeciosa EU045438
98
▲ Heterodermia dissecta EU045424
Group I: lower cortex present
▲ Heterodermia hypoleuca EU045429
74
▲ Heterodermia hypoleuca EU045428
100
▲ Heterodermia microphylla EU045433
50
61
▲ Heterodermia microphylla EU045434
▲ Heterodermia obscurata EU045436
Monophyletic clade
100
▲ Heterodermia obscurata EU045435
Group II: lower cortex absent
100
▲ Heterodermia subascendens EU045441
100
▲ Heterodermia subascendens EU045442
▲ Heterodermia hypochraea EU045427
100
▲ Heterodermia boryi EU045422
63
▲ Heterodermia boryi EU045423
76
▲ Heterodermia japonica EU045431
100
▲ Heterodermia japonica EU045432
Anaptychia palmatula DQ394370
Anaptychia ciliaris AF389939
100
99
Anaptychia runcinata AF224364
93
Anaptychia bryorum AF250781
92
Anaptychia ulotricoides AF540494
100
Anaptychia elburzuana AY368145
0.05

Fig. 2. NJ consensus tree based on nrDNA ITS sequences. Nucleotide: Kimura 2-parameter, pairwise deletion, bootstrap=1000. The numbers in each node represents bootstrap support value, and the numbers lower than 50 were not shown. The sequences marked with ▲were obtained in this study, and others were downloaded from GenBank.

Group II shows species with a yellow pigment at the lower surface (*H. hypochraea*, *H. subascendens*, *H. obscurata*) in one cluster separated from species lacking this yellow pigment (*H. boryi*) or only sometimes possessing the pigment (*H. japonica*), suggesting that presence or absence of yellow pigment may serve as a helpful taxonomic character. Although there is only a short genetic distance separating *H. hypoleuca* and *H. microphylla,* we think they should be treated as two different species based on the phenotype showing two taxa are easily distinguished phenotypically by rhizine color and the presence or absence of soredia.

Based on our experimental results, we conclude that the genus *Heterodermia* forms a well-supported monophyletic clade. We also identify four characters as important for separating taxa within *Heterodermia*: (i) cortication of the lower surface (Fig.3A, B), (ii) presence or absence of soredia (in some cases, Fig.3D), (iii) presence or absence of a yellow pigment (Fig.3C), and (iv) the presence or absence of norstictic and salazinic acids.

Taxonomy

Based on the comprehensive analysis given above, a key to the species is presented, in which seven additional species not examined in our study but reported before in South Korea are also included. All treated taxa are subsequently listed and include diagnostic characters of each species. In case of large numbers of studied specimens only some representative specimens are cited.

Key to the species of Heterodermia in South Korea

1. Isidia present	*H. isidiophora*
1. Isidia absent	2
2. Lower surface corticate	3
2. Lower surface not corticate	7
3. Rhizines marginal	*H. rubescens*
3. Rhizines not marginal	4
4. Lobes sorediate	5
4. Lobes esorediate	6
5. Norstictic acid present	*H. pseudospeciosa*
5. Norstictic acid absent	*H. speciosa*
6. Norstictic and salazinic acids absent; lobules marginal and laminal	*H. diademata*
6. Norstictic and salazinic acids present; lobules only marginal	*H. dissecta*
7. Long and white cilia present	*H. comosa*
7. Cilia absent	8
8. Medulla yellow	*H. firmula*
8. Medulla white	9
9. Lower surface K+ purple-red, yellow pigment present	10
9. Lower surface K-, yellow pigment absent	15
10. Thallus esorediate	11
10. Thallus sorediate	14
11. Lower surface purple-black at center	12
11. Lower surface white at center	13
12. Rhizines white	*H. loriformis*
12. Rhizines black	*H. dendritica*
13. Unknown yellow substance present	*H. pandurata*
13. Unknown yellow substance absent	*H. hypochraea*
14. Soredia at lower surface, non-labriform	*H. subascendens*
14. Labriform soralia	*H. obscurata*
15. Thallus esorediate	*H. hypoleuca*
15. Thallus sorediate	16
16. Soredia laminal, mixed with lobules	*H. microphylla*
16. Soredia marginal or terminal	17
17. Soredia terminal; thallus foliose	*H. japonica*
17. Soredia marginal; thallus subfiliform	*H. boryi*

Heterodermia Trevis., Atti Soc. Ital. Sci. Nat. (Milano) 11: 613. 1868

Lectotype: *H. speciosa* (Wulfen) Trevis. (selected by Poelt 1965).

1. ***Heterodermia boryi*** (Fée) K.S. Singh & S.R. Singh, Geophytology 6 (1): 33, 1976

REMARKS: *H. boryi* is easily characterized by its strap-shaped to subfiliform lobes, circinate tips, and the round or patch-shaped soralia that are lateral and laminal.

SPECIMENS EXAMINED: KOREA. Mt. Jiri, N35°19'09.1", E127°40'26.9", alt. 1620 (1564) m, on rock, 23 April 2004, Hur 040329; Mt. Jiri, N35°19'07.0" E127°40'42.7", alt. 1580(1531) m, on rock , 23 April 2004, Hur 040340; Jejudo, N33°21'32.9" E126°31'54.9", alt. 1920 m, on rock, 27 August 2004, Hur 040754.

2. ***Heterodermia diademata*** (Taylor) D.D. Awasthi, Geophytology 3: 113, 1973

REMARKS: *H. diademata* is characterized by a sublinear thallus, the abundance of marginal and laminal lobules, and a corticate lower surface (Fig. 3B). The species is similar to *H. dissecta* in morphology, but differs in chemistry, salazinic and norstictic acids absent in *H. diademata*, while present in *H. dissecta*.

SELECTED (OF 30) SPECIMENS EXAMINED: KOREA. Mt. Naejang, alt. 680 m, on rock, 29 June 2003, Hur 030429; Baekdam temple, N38°11'16.4" E128°21'42.7", alt. 450 m, on rock, 11 October 2004, Hur 041509; Mt. Jiri, N35°20'31.5" E127°41'08.9", alt. 715 m, on bark, 4 September 2004, Hur 040928; Mt. Deogyu, N35°51'24.1" E127°44'53.6", alt. 1580 m, on bark, 3 April 2005, Hur 050093; Mt. Sorak, N38°09'18.1" E128°19'46.1", alt. 880 m, on bark, 16 June 2005, Hur 050273; Wando arboretum, N34°21'10.3" E126°41'10.9"alt. 535 m, on rock, 13 April 2005, Hur 050133.

3. ***Heterodermia dissecta*** (Kurok.) D.D. Awasthi, Geophytology 3: 113, 1973

REMARKS: *H. dissecta* is characterized by sublinear lobes, the abundance of marginal (occasionally laminal) lobules, and a corticate lower surface. The species is similar to *H. diademata* in morphology, but differs in chemistry, with salazinic and norstictic acids present in *H. dissecta* and absent in *H. diademata*.

SPECIMENS EXAMINED: KOREA. Mt. Baega, N34°10'14", E127°8'45", alt. 500 m, on rock, 8 October 2005, Hur 050572. Mt. Chiri, N35°19'1", E127°44'30.1", alt. 1160 m, on rock, 15 September 2006, Hur 060639.

4. ***Heterodermia hypochraea*** (Vain.) Swinscow & Krog, Lichenologist 8 (2): 119, 1976

REMARKS: *H. hypochraea* has a papillate upper surface, erect lobe tips, and an ecorticate lower surface with a yellow pigment (Fig. 3C). The species is similar to *H. hypoleuca* in morphology, but differs in its white rhizines, erect lobe tips, and yellow lower surface.

SPECIMEN EXAMINED: KOREA. Jejudo, N33°24'26.6" E126°29'46.0", alt. 645 m, on bark, 26 August 2004, Hur 040658.

5. ***Heterodermia hypoleuca*** (Mühl.) Trevis., Atti Soc. ital. Sci. nat. (Milano) 11: 615, 1868

REMARKS: *H. hypoleuca* has a maculate upper surface, an ecorticate lower surface (Fig. 3A), center that is reticulately veined, and hyaline to tan rhizines. This species

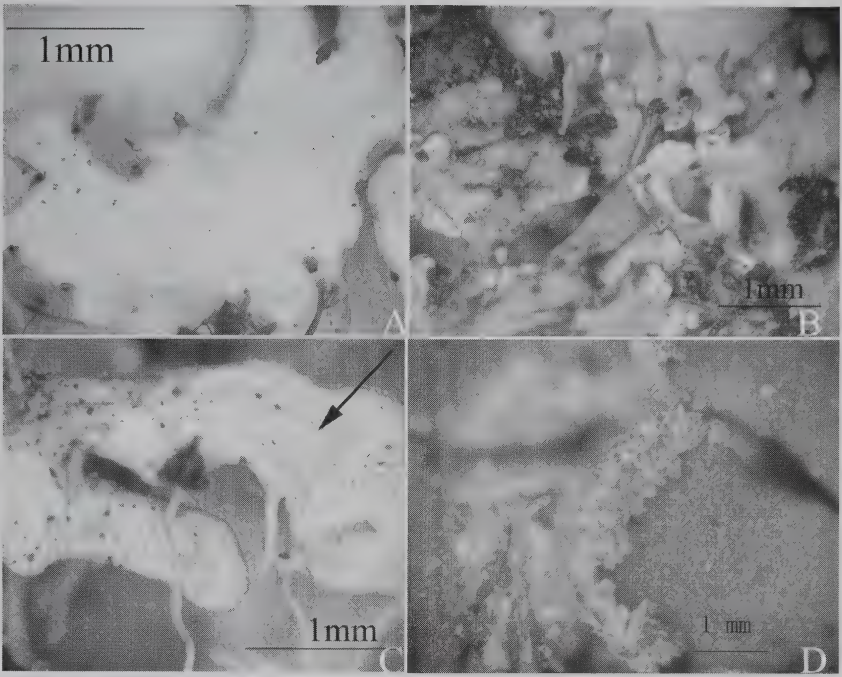

Fig. 3. A. Ecorticated lower surface of *Heterodermia hypoleuca*, Hur 030174; B. Corticated lower surface of *H. diademata*, Hur 030429; C. Yellow pigment (arrow) at the lower surface of *H. hypochraea*, Hur 040658; D. Labriform soralia of *H. pseudospeciosa*, Hur 030204.

is similar to *H. hypochraea*, but differs by the tan colored rhizines, the plane lobe tips, and the absence of a yellow pigment in the lower surface. *H. hypoleuca* is also similar to *H. japonica* in morphology, but differs in that *H. hypoleuca* has hyaline to tan rhizines and lacks soredia.

Selected (of 107) specimens examined: KOREA. Mt. Baekwoon, alt. 1050 m, on rock, 5 May 2003, Hur 030174; Mt. Hanla, alt. 1300, on moss, 22 June 2003, Hur 030333; Mt. Sobaek, N36°56'50.5" E128°29'51.2", alt. 1110 m, 2 October 2003, Hur 030752; Mt. Gaya, N35°48'28.5" E128°07'00.6", alt. 965(916) m, on rock, 15 April 2004, Hur 040196; Mt. Odea, N37°43'42.8" E128°35'36.6", alt. 650(662) m, on *Abies*, 7 May 2004, Hur 040400; Jejudo, N33°25'21.9" E126°33'35.7", alt. 505(614)m, on bark, 26 August 2004, Hur 040676; Mt. Taebaek, N37°06'00.3" E128°57'02.5", alt. 1220 m, on bark, 12 September 2004, Hur 041046; Mt. Naejang, N35°29'46.1" E126°53'56.7", alt. 600 m, on bark, 8 January 2005, Hur 050017; Mt. Deogyu, N35°51'29.2" E127°45'03.4", alt. 1530 m, on bark, 2 April 2005, Hur 050079; Mt.Chiri, N35°17'35.3" E127°32'50.3", alt. 1390 m, on *Quercus*, 17 June 2006, Hur 20060232.

6. *Heterodermia japonica* (M. Satô) Swinscow & Krog, Lichenologist 8 (2): 122, 1976

Remarks: *H. japonica* is characterized by ascending lobe tips, labriform to subcapitate soralia, an ecorticate lower surface, and the presence ('*H. propagulifera*') or absence

(*H. japonica* s.str.) of a yellow pigment. This species is similar to *H. hypoleuca*, but differs in having black rhizines and labriform to subcapitate soralia at the lobe tips.

> Selected (of 46) specimens examined: KOREA. Mt. Baekwoon, alt. 705 m, on bark, 1 June 2003, Hur 030282; Mt. Taebaek, N37°06'21.7" E128°57'12.1",alt. 1025 m, on rock, 2 November 2003, Hur 030841;Jejudo,33°24'26.6" E126°29'46.0", alt. 645 m, on bark, 26 August 2004, Hur 040654; Mt. Sorak, N38°06'40.4" E128°24'26.8", alt. 1335 m, on *Abies*, 10 October 2004, Hur 041460; Mt. Deogyu, N35°47'19.4" E127°42'30.3", alt. 1269 m, on rock, Hur 050207; Mt.Chiri, N35°18'14" E127°34'10.4", on 1430 m, on rock, 17 June 2006, Hur 060291.

7. *Heterodermia microphylla* (Kurok.) Skorepa, Lichenologist 8 (2): 132, 1976

Remarks: *H. microphylla* has labriform soralia and the abundance of erect lobules (mixed with granular soredia) on the upper surface. This species is similar to *H. hypoleuca*, but differs in having labriform soralia, marginal and laminal lobules, and granular soredia and lobules mix o the upper surface.

> Selected (of 36) specimens examined: KOREA. Mt. Naejang, alt. 695 m, on rock, 29 June 2003, Hur 030427; Mt. Taebaek, N35°29'46.9" E126°53'40.7", alt. 1025 m, on rock, 2 November 2003, Hur 030837; Jejudo, N33°21'32.3" E126°31'23.5", alt. 1920 m, on bark, 27 August 2004, Hur 040762; Mt. Jiri, N35°17'25.78" E127°31'59.7", alt. 1420 m, on *Quercus*, 17 June 2006, Hur 060173; Mt.Deogyo; N35°51'10.0" E127°44'56.9", alt. 1568 m, on bark, 10 August 2006, Hur 060494; Mt.Baewoon, N35°36'31.3" E127°38'25.6", alt. 1140 m, on *Quercus*, 17 August 2006, Hur 060605; Mt.Songni, N36°32'39.7" E127°51'49.3", alt. 700 m, on rock, Hur 060048.

8. *Heterodermia obscurata* **(Nyl.) Trevis., Nuovo Giorn. Bot. Ital. 1: 114, 1869**

Remarks: *H. obscurata* has labriform soralia, marginal lobules, yellow pigmented lower surface, and by black rhizines. Similar to *H. subascendens*, but differs in the occurrence of a yellow pigment (which covers almost all the lower surface), the black rhizines, and the striking labriform soralia at the lobe tips.

> Specimens examined: KOREA. Sorokdo, alt. 15 m, on bark, 23 March 2003, Hur 030034; Mt. Gaya, alt. 40o m, on bark, 22 April 2003, Hur 030153; Jejudo, N33°28'25.5" E126°29'47.7", alt. 145 m, on bark, 26 August 2004, Hur 040623; Jejudo, N33°25'21.9" E126°33'35.7", alt. 505(614) m, on bark, 26 August 2004, Hur 040680-1; Jejudo, N33°27'15.4" E126°33'41.1", alt. 370 m, on bark, 29 August 2004, Hur 040863, 040867; Mt. Wonlak, on bark, 18 September 2004, Hur041171; Wando arboretum, 34°21'10.3" E126°41'10.9", alt. 535 m, on rock, 13 April 2005, Hur 050136; Mt. Hegsog, N34°41'21.4" E126°40'51.4", alt. 203 m, on rock, 23 September 2005, Hur 050462.

9. *Heterodermia pseudospeciosa* (Kurok.) W.L. Culb., Bryologist 69: 484, 1967

Remarks: *H. pseudospeciosa* is characterized by labriform soralia, lateral branches with subcapitate soralia, and a corticate lower surface. The species is similar to *H. speciosa* in morphology, but differs in chemistry. Norstictic and salazinic acids are present in *H. pseudospeciosa*, while absent in *H. speciosa.*

> Specimens examined: KOREA. Mt. Jiri, alt. 515 m, on rock, 4 May 2003, Hur 030204; Mt. Baekwoon, alt. 700 m, on rock, 1 June 2003, Hur 030281; Mt. Kem, N34°45'32.3"

E127°59'31.9", alt. 340(310) m, on rock, 15 Febuary 2004, Hur 040033; Baegdam temple, N38°11'16.4" E128°21'42.7", alt. 450 m, on rock, 11 October 2004, Hur 041508; Mt. Hegsog, N34°41'21.4" E126°40'51.4", alt. 203 m, on rock, 23 September 2005, Hur 050451; Mt. Hegsog, N34°41'21.1" E126°40'47.5", alt. 230 m, on rock, 23 September 2005, Hur 050493; Mt. Juwang, N36°23'58.9" E129°09'53.1", alt. 310 m, on rock, 16 October 2005, Hur 050618; Mt.Songni, N36°32'41.6" E127°51'19", on *Quercus*, 10 August 2006, Hur 060025.

10. *Heterodermia speciosa* (Wulfen) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 614, 1868

Remarks: *H. speciosa* has capitate soralia on the tips of lobes and lobules, and a lower cortex. The species is similar to *H. pseudospeciosa* in morphology, but differs in chemistry. Norstictic and salazinic acids are absent in *H. speciosa*, while present in *H. pseudospeciosa.*

Specimens examined: KOREA. Jejudo, alt. 145 m, on bark, 26 August 2004, Hur 040615; Jejudo, N33°28'25.5" E126°29'47.7", alt. 145 m, on bark, 26 August 2004, Hur 040620; Jejudo, N33°27'15.4" E126°33'41.1", alt. 370 m, on bark, 29 August 2004, Hur 040849; Mt. Juwang, N36°24'09.6" E129°10'27.0", alt. 380 m, on rock, 15 October 2005, Hur 050602.

11. *Heterodermia subascendens* (Asahina) Trass, Folia cryptog. Estonica 29: 20, 1992

Remarks: *H. subascendens* is characterized by its maculate upper surface, marginal and grayish white rhizines, an ecorticate yellow lower surface and granular soredia near lobe tips. The species resembles *H. hypoleuca* in morphology, but differs in the color of rhizines, the presence of a yellow pigment, and the presence of granular soredia on the lower surface. It is also similar to *H. hypochraea*, differing in the color of rhizines and the presence of granular soredia on the lower surface.

Specimens examined: KOREA. Sorokdo, alt. 15 m, on bark, 27 December 2003, Hur 030895; Jejudo, N33°28'25.5" E126°29'47.7", alt. 145 m, on bark, 26 August 2004, Hur 040619; Jejudo, N33°27'15.4" E126°33'41.1", alt. 370 m, on bark, 29 August 2004, Hur 040847.

Earlier reports on further species, not found in the present study

An additional seven species previously recorded from the Korean peninsula but not found in our recent surveys are included in the key according to descriptions provided in the literature.

1) *Heterodermia comosa* (Eschw.) Follman & Redón, Willdenowia, 6: 446, 1972

Its striking diagnostic character is the presence of long and white cilia on the lobe edges. In Korea, the species has been recorded only once at a single locality on Jeju Island by Kashiwadani et al. (2002). It is widely distributed in tropical regions of Asia and America (Kurokawa 1962).

2) ***Heterodermia dendritica*** (Pers.) Poelt, Nova Hedwigia 9: 31, 1965

The species is characterized by absence of soredia, often pruinose margins, lower surface ecorticate, white, purple-black only at center, partly yellow pigmented. The taxon is similar to *H. propagulifera*, but differs in the absence of soredia. Kurokawa (1962) included *H. propagulifera* as a variety in *H. dendritica* (as *Anaptychia*). In Korea, this species has been once recorded from Mt. Jiri by Park (1990).

3) ***Heterodermia firmula*** (Nyl.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 615, 1868

The diagnostic character of this species is the yellow medulla. It is close to the endemic Indian species *H. albidiflava* (Kurok.) D.D. Awasthi, which shows a PD+ deep-yellow reaction (unknown substance). In Korea, *H. firmula* was recorded only once from Mt. Sobaek by Park (1990). However, we found no species with a yellow medulla on this mountain, although we have many specimens collected there.

4) ***Heterodermia isidiophora*** (Nyl.) D.D. Awasthi, Geophytology 3: 114, 1973

Heterodermia isidiophora is a peculiar species in having corticate lower surface and isidia in upper surface. In Korea, the species has been recorded by Park (1990). However, during our study, all the similar specimens with isidia are *Anaptychia* species, containing no chemical substances, so, whether *H. isidiophora* really exists in South Korea still needs further study.

5) ***Heterodermia loriformis*** (Kurok.) Swinscow & Krog, Lichenologist 8: 129, 1976

Heterodermia loriformis is a peculiar species in having a white ecorticate lower surface with zones of a yellow pigmentation and white rhizines. Similar to *H. dendritica*, but differs in its white rhizines. In Korea, the species has been recorded only once by Park (1990) as *H.* cf. *loriformis* based on specimens from Mt. Jiri. However, Moon (1999) identified the specimens as *H. pandurata*. Further studies are still needed to clarify the identity of the taxon.

6) ***Heterodermia pandurata*** (Kurok.) J.C. Wei, An enumeration of lichens in China, p. 112, 1991

This species was reported by Moon (1999) on Mts. Jiri and Kaya of Korea. It is very similar to *H. hypochraea*, but differs in presence of unknown yellow substance (Kurokawa 1962). We didn't find this species during our study.

7) ***Heterodermia rubescens*** (Räsänen) D.D. Awasthi, Geophytology 3: 114, 1973

The species is characterized by a corticate lower surface and by mainly marginal rhizines. It had been known only from India until Moon (1999) reported it from Korea. The voucher specimens are deposited in TNS (Japan), and we found no corresponding specimens in our study.

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Scutellospora striata sp.nov., a newly described glomeromycotan fungus from La Gran Sabana, Venezuela

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Abstract — Examination of soil samples from a sclerophyllous shrubland near the town of Iboribó in La Gran Sabana, Venezuela, revealed an undescribed species of *Scutellospora* whose spores are ornamented with finger-print-like processes, are ochraceous yellow with a pinkish tint, and have a complex wall structure. The new species, named *Scutellospora striata*, is the third *Scutellospora* species described from La Gran Sabana, Venezuela.

Key words — arbuscular mycorrhizal fungus, AMF, *Gigasporaceae*, taxonomy, tropical species

Introduction

The La Gran Sabana region is located in southeastern Venezuela, South America. It is a highly undulate plain occupying ca. 30.000 km^2 of a slope from 1450 m to 750 m above sea level directed from the north to the south. This mosaic of igneous and metamorphic rock is one of the earliest shields of the earth crust. It formed the western section of the ancient supercontinent of Gondwana (Schubert & Huber 1989). It was formed in Precambrian age and due to its antiquity and advanced phase of weathering, soils originated from that substrate (Roraima Formation) are mainly sandy with a very small clay fraction and generally very low nutrient content. La Gran Sabana is also the land of the tepuis, which are mountains of vertical walls and flat hilltops (tablelands), and an outstanding region due to the high degree of endemism of its flora (Rull 1991). The plant cover of La Gran Sabana is an intricate mosaic, composed of numerous types of vegetation. With the exception of the continuous forests at the foot of the eastern tepuis, forests occur in patches encircled by extensive treeless savannas, as well as by shrublands (Dezzeo 1994).

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†Dr. Herrera-Peraza passed away in December of 2006.

Shrublands are primary plant communities in which the shrub stratum constitutes the principal functional compartment. They consist of a well-developed shrubby stratum 1-3 m high, occasionally with emergent shrubs up to 5 or 7 m tall, with predominantly sclerophyllous leaves (Huber 1994), which almost always grow on rocky sandstone outcroppings or on white quartzitic sands. According to Huber & Febres (2000) they contain a significant number of endemic plants.

During the inventory of the arbuscular mycorrhizal fungi (AMF) associated with the sclerophyllous shrublands of La Gran Sabana, spores of an undescribed species of the genus *Scutellospora* with a distinctive ornamentation were found. The fungus is described here as *S. striata* sp. nov.

Material and methods

Intermittent soil samples were taken during two years below vegetation in a sclerophyllous shrubland situated at Iboribó (5°36.796'N, 61°29.351'W) in La Gran Sabana. This shrubland grows on sandstone outcrops (Huber 1994). It is highly diverse in plant species, but among the most common are *Clusia pusilla, Gongylolepis benthamiana, Euphronia guianensis, Humiria balsamifera, Calliandra* sp., *Bonnetia sessilis* and some small rosettes belonging to the *Cyperaceae* family such as *Rhynchospora barbata* and *Bulbostylis conifera.* Open pot trap cultures started from these soils were maintained in a glasshouse for three months and then dried for one week. The content of the pot was stored at room temperature (≈20°C) for almost one year to break latency of spores (Morton et al. 1993). Then, spores were isolated and used to start pure cultures that all failed. Therefore, the description of the species presented below was prepared based on spores isolated only from trap cultures and field soils. The cultures were initiated with *Vigna luteola* as the host plant, but it died and then was replaced by wild plants germinating from the seed bank. Various very interesting species of *Scutellospora* spp. were isolated from this place (Herrera-Peraza et al. 2001, Walker et al. 1998). However, no pure culture of any of them could be obtained.

Spores were isolated from the trap pots or from the field soils by wet sieving, decanting and sucrose centrifugation (Sieverding 1991). The isolated spores were suspended in water and illuminated with light from a quartz-iodine fibre-optic source. Their color was determined by comparison with a color chart for British fungi (Anon 1969). The specimens were mounted in polyvinyl alcohol lacto-glycerol (PVLG) or in PVLG mixed with Melzer's reagent (1:1, v/v). Wall description and terminology are based on those suggested by Walker (1983) and Walker & Vestberg (1998). Type material has been deposited in the Venezuelan National Herbarium (VEN) and the Cuban National Herbarium, IES-CITMA (HAC).

To study more carefully the external appearance of the spores, a number of them were prepared for Scanning Electron Microscopy (SEM). Prior to the preparation of the material for SEM, spores were put under a dissecting microscope to remove or to break the outer unit component with the aid of fine tweezers. Then, intact or broken spores were rinsed in a phosphate buffer solution and immediately fixed in 1% osmium tetroxide at 4°C for 1 h. Fixed samples were dehydrated for 5 min in each dilution of an acetone series (20, 40,70,80 and 100 %), dried at critical point with liquid CO_2, placed on aluminum metal holders, coated with 200 Å gold-palladium and observed for SEM.

Taxonomic description

Scutellospora striata Cuenca & R.A. Herrera **sp.nov.** Figures 1-3

MycoBank MB 511702

Spore singulatim enatae in solo, ochraceae roseo suffusae, superficie nitida, vulgo globosae vel subglobosae, 130–184 × 116–152 µm, supra suspensorem bulbosum ochraceum locatae. Sporae parietum structura 6-tunicata. Tunicae prima et secunda respective unitaria et laminata, caeterae omnes membranaceae. Tunica prima 1.5–2 crassa, laevis. Tunica secunda 5–10 µm crassa ochracea, in juventute tenuiter laminata et ornata muris 1.0–1.5 µm latis, invicem 0.5–0.8 µm separatis, striatim dispositis, vestigia digitalia referentibus. Tunica tertia, 0,7 µm crassa, rigida, firmiter tunicae secundae adpressa. Tunica quarta, quinta et sexta, flexibles, membranaceae. Tunica quarta difficilis visu, sed Melzeris reactivo dilute rosea evadens. Tunica quinta et sexta firmissime adpressae, solum sub microscopio Normanski obviae, vel sexta Melzeris reactivo purpurea evadens. Scutellum germinativum varie et dense plicatum. Cellulae auxiliares nobis non observatae.

Holotype: Slide no. Cuenca 479-4, 13 Feb. 1998, Venezuelan Institute for Scientific Research.

Etymology Latin *striata* "with striae", referring to the spore ornamentation composed of elongated, generally parallel elements separated by grooves.

Spores borne singly in soil, ochraceous yellow of a pinkish tint in color (Ochraceous [8G] to Saffron [49] according to the color chart), having a shinning surface when observed under a dissecting microscope and illuminated with tungsten lamp, generally globose or subglobose (Fig. 1a), 130–184 × 116–152 µm (mean 163 × 152 µm, n= 13) with a terminal attached bulbous base, produced from a septate subtending hypha. Bulbous spore base ochraceous yellow in color and 22–29 µm wide, with a recurved septum at its base.

Spore wall structure composed of 6 components or layers generally organized in 3 groups. With the exception of components 1 and 2, being unit and laminated, respectively, all the remaining components are membranous. Component 1 is contiguous with the sporophore outer wall component, 1.5–2.0 µm thick, and have a smooth surface (Figs. 2a, b and 3). Component 2 is laminated, 5.0–10.0 µm thick, and ochraceous yellow (Fig. 3). In young spores the component 2 is finely laminated and ornamented with muri 1.0–1.5 µm wide and spaced 0.5–0.8 µm apart (Fig. 1b). When seen in a plane view, the muri resemble a finger-print. When spores develop 1 to 3 thick laminae (1.0–2.0 µm thick) originate from component 2 outwards (Figs. 3a-c). Each of these laminae have the same ornamentation as described above. When three laminae are formed, next fine inseparable laminae are synthesized inward. (Fig. 3c). As mentioned before, each thick lamina is ornamented on the upper surface with muri showing a striate pattern. The muri are commonly squared, angular or wave-like in a cross section. The striations rarely follow the same direction on the surface of each of the thick laminae and, thereby, in a plane view the spore ornamentation seems to be composed of tiny squares or rhombs (Fig. 1c). At each two-muri interception wall material is deposited to form a small columella. Therefore, in a cross section the component 2 is composed of up to three lines of rounded cavities resulting from inter-muri and columella interspaces (Fig. 2c).

Component 3, measuring approx. 0.7 µm, is a rigid membrane tightly adhered to the lower surface of component 2 or separates from it in vigorously crushed spores (Fig. 1h). Components 4 to 6 are flexible membranes usually tightly adherent to each other.

Component 4 is generally very difficult to discern (Fig. 1f), but its presence becomes evident in Melzer's reagent because it reacts pale pink (Fig. 1g). Components 5 and 6 are firmly cemented in between and can be discerned only under a microscope equipped with Nomarski interference contrast or in spores crushed in Melzer's reagent because component 6 becomes readily purple in it. None of these innermost membranes are beaded or amorphous. Germination shield 64 × 72 µm in size with complex infolding (Figs. 1e and 3b).

BULBOUS SPOROPHORE lacks ornamentation. The wall of the sporophore is composed of two layers that are contiguous with components 1 and 2 of the spore wall (Figure 1d). This wall is 1.5–2.0 µm thick, reaching up to 3.0–5.0 µm near the spore base. The pore at the attaching point is approximately 1.0 µm diam. Hyphae attached to the sporophore are regularly septated, measuring 5.0–9.0 µm diam., and have walls 1.0–2.0 µm thick. Auxiliary cells unknown.

DISTRIBUTION AND HABITAT. Known only from La Gran Sabana, Venezuela. Spores of this species have been collected only from the sclerophyllous shrubland at Iboribó and in a treeless savanna dominated by *Axonopus canescens*, also in the way to the Iboribó shrubland. Soils are highly acidic, sandy with a very low exchangeable phosphorus and medium level of total N.

MYCORRHIZAL ASSOCIATIONS unknown. Attempts to form mycorrhizae in pure culture have failed, though the species sporulated in a multispecies pot culture with *Scutellospora spinosissima*, and other unknown species of *Acaulospora*, *Glomus*, and *Scutellospora*.

COLLECTIONS EXAMINED: Type. Isolated from trap culture at the Venezuelan Institute for Scientific Research, Caracas, Venezuela. Holotype slide no. Cuenca 479-4, 13 Feb. 1998. Isotypes: Cuenca 411-17, March 1997, Cuenca 386-1, 19 Dec. 1996.

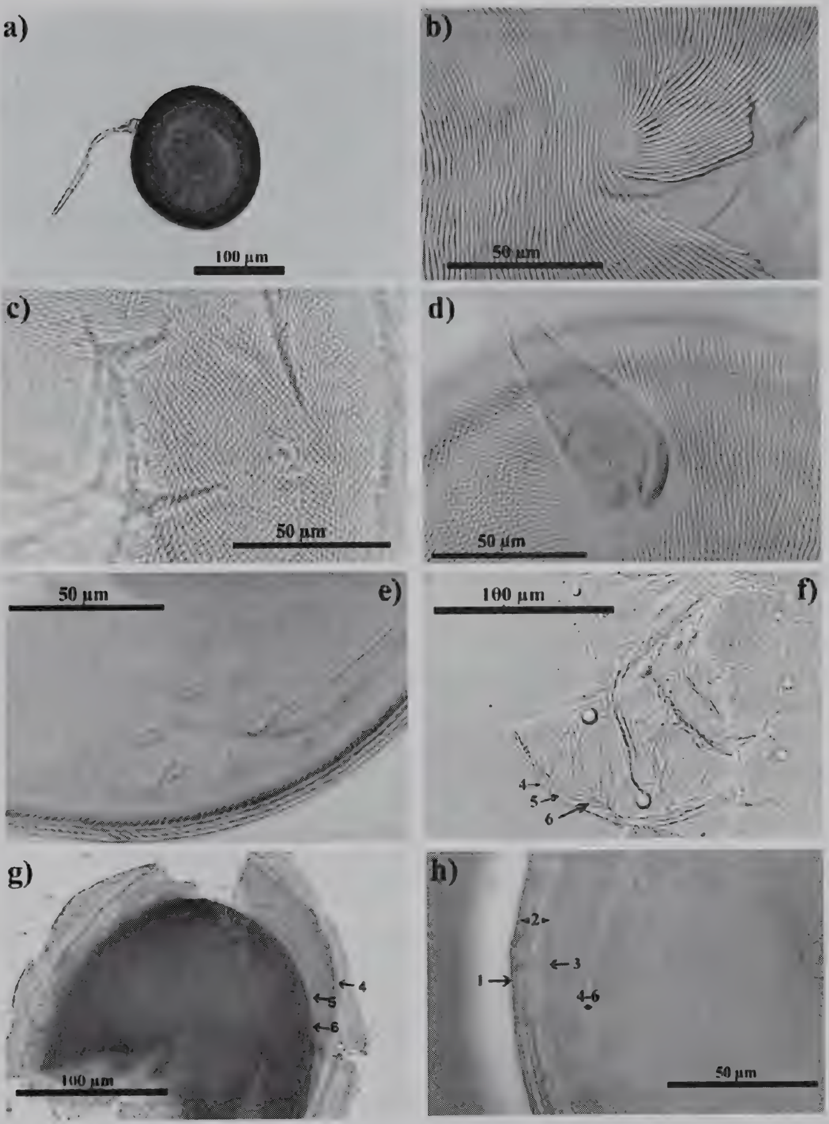

Figure 1. *Scutellospora striata*. a) Intact spore mounted in PVLG. b) Ornamentation of spore wall component 2 seen in a plane view. c) Ornamentation of spore wall component 2 of older spore. It resembles rhombs due to the overlapping laminae, each ornamented with striae. d) Non-ornamented bulbous suspensor. e) Germination shield. f) Crushed spore with inner group of membranous components. Most internal components are labeled. g) Heavily crushed spore mounted in PVLG+Melzer's reagent with stained components 4 and 6. h) Cross view of spore with components 1-6 arranged in two groups.

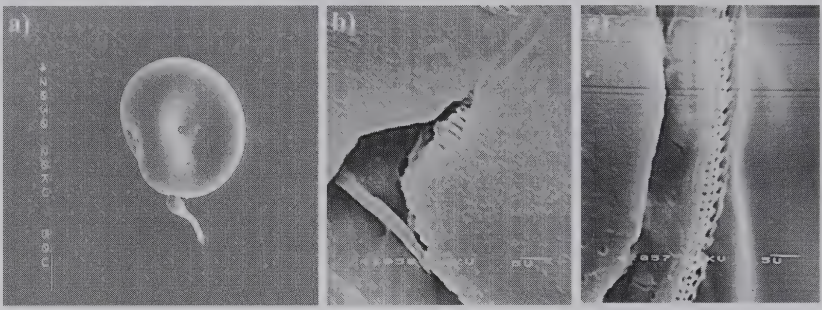

Figure 2. SEM images of *S. striata*. a) Intact spore with the outermost unit component obscuring the ornamented spore wall component 2. b) The striae on the upper surface of component 2 visible through the broken component 1. c) Cross view of component 2 with lines and round cavities.

Discussion

Scutellospora striata can be readily distinguished from other species in the genus by its peculiar ornamentation. Under a dissecting microscope, the ornamentation is not always evident, because the unit outer component is smooth and usually shines under incident light, though it detaches from the spore easily after low pressure. The presence of the very robust component 1 was evidenced by SEM (Fig. 2a). It has a smooth surface, which is often free of organic debris. However, in some spores lacking the outer component 1, fine soil debris firmly adhere to the spore surface, which show the ornamentation when detached. The ornamentation of component 2 could be visualized under SEM only after manipulating the spore to break the outer unit component (Fig. 2b).

Component 2 is quite complex. Because each layer of the laminated component 2 is ornamented with striae, in a plane view the striae of overlapping layers are visible as tiny squares or rhombs (Fig. 1c). When spores are very young and only one layer (subcomponent) of component 2 is differentiated or when the outermost subcomponent is in focus, the ornamentation resembles a finger-print (Figs. 1b and 3a).

Assessing the number of wall components is very difficult. The number of inner components may be determined when first intact spores are mounted in PVLG for 1-2 hours and crushed by applying pressure to the cover slip to

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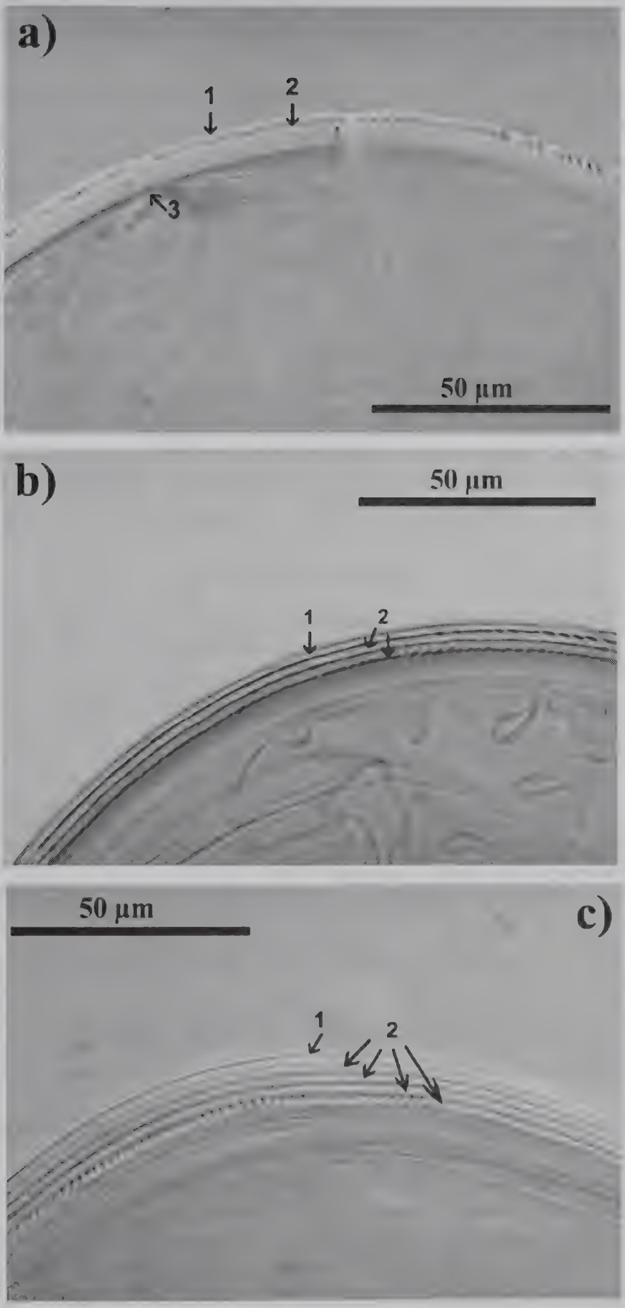
Figure 3 (on next page). Differentiation of the laminate spore wall component 2 of *S. striata*. a) Only one lamina of component 2 of young spore. Outer unit component 1 is transparent and easy to see. b) Component 1 and two laminae of component 2 of older spore. Germination shield is also visible. c) Component 1 and four laminae of component 2 of mature spore.


a)
1
2
3
50 µm
b)
50 µm
1
2
c)
50 µm
1
2

push the internal membranes out (Fig. 1f). Component 4 may also be revealed in spores crushed in PVLG+Melzer's reagent, because it stains light pink (Fig. 1g).

The sporulation of *S. striata* in both trap cultures and the field was not abundant. Unfortunately, attempts to grow this fungus in one-species cultures failed and, hence, the properties of its mycorrhizae remain unknown, similar to those of many other unculturable members of the *Glomeromycota* (Fitter 2005).

Of the described species of the genus *Scutellospora*, eleven produce ornamented spores. However, while the ornamentation of *S. striata* spores consists of striae resembling a finger-print when seen in a plane view, that of spores of *S. coralloidea*, *S. dipapillosa*, *S. gregaria*, *S. heterogama*, *S. persica* and *S. verrucosa* is composed of warts, *S. crenulata* of dome-like subpolygonal papillae separated by pits, *S. minuta* of spines with round apices, *S. nigra* of pits, *S. nodosa* of knobs, and *S. spinosissima* of blunt spines.

In addition to *S. crenulata* and *S. spinosissima*, *S. striata* is the third newly described species from La Gran Sabana, Venezuela.

Acknowledgments

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Arthonia hawksworthii sp. nov. (*Ascomycota, Arthoniaceae*) on *Dimelaena oreina* from Turkey

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Abstract — *Arthonia hawksworthii* is described on the thallus of *Dimelaena oreina* from two localities in Turkey. It is most similar to *A. gelidae*, a lichenicolous species confined to *Placopsis gelida*, but mainly differs from this species in that it has ascospores with a gelatinous sheath that stain red in I-Lugol and an epithecium that is light to dark brown with an olivaceous tinge in KOH. The new species is the first *Arthonia* species reported on *Dimelaena*.

Key words —fungi, lichens, taxonomy

Introduction

The genus *Arthonia* Ach. includes c. 500 species, the majority of which are lichenized (Hawksworth et al. 1995). The current concept of the genus is rather broad, as it includes some species with and others without a K/I+ blue ring in the tholus, and the interascal filaments are highly variable within the genus (Coppins 1989, Grube & Matzer 1997). Grube & Matzer (1997) provided useful taxonomical characters for *Arthonia* species, focusing primarily on lichenicolous taxa.

Material and methods

The type of the new species is deposited in the herbarium at the Erciyes University, Department of Biology, Kayseri. Specimens were examined with an Olympus BH-2 research microscope fitted with Nomarski differential interference contrast optics and a drawing tube. Sections were prepared by hand and examined in I (Lugol's iodine (MERCK 9261) and Meltzer's iodine, with [KI] and without [I] pre-treatment with 10% KOH), 10% KOH, and water. Ascospore measurements were taken in water; the extreme values outside the main range are seen in parentheses. The length/breadth (l/b) ratio of the ascospores is provided in the same way.

The species

Arthonia hawksworthii Halici, **sp. nov.** FIGURE 1

MycoBank MB 511724

Fungus in thallo Dimelaenae oreinae incolens. Apothecia nigra, 0.1- 0.4 mm diam. Epithecium 10–20 µm altum, olivaceo-brunneum. Hymenium 50–65 µm altum, hyalinum. Hypothecium 10–15 µm altum, hyalinum vel pallide brunneum. Asci (23–)27–38 × 14–18(–22) µm, clavati, octospori. Ascosporae 1- septatae, hyalinae, halonatae, (10–)11.5–14 × 4–5.5(–6.5) µm, l/b = (1.8–)2.3–3.0(–3.5).

Typus: Turkey, Yozgat, Çayıralan District, Elçi Village, 39°15'N, 35°39'E, alt. 1720 m, on thallus of *Dimelaena oreina* on siliceous rocks, 14 August 2004, leg. M. G. Halıcı 0.1386 (herbarium of Erciyes University – holotypus).

Etymology: Named in honour of David L. Hawksworth, one of the pioneers of lichenicolous fungi and a tutor of the author.

Description: Lichenicolous, on the thalli of *Dimelaena oreina*, causing slight bleaching, weakly parasitic. Ascomata apothecia, numerous, dispersed on the surface of the host areoles, black, epruinose, superficial, plane at first, soon becoming ± convex, 0.1–0.4 mm diam, 2–4 per areole, lacking an exciple, arthonioid. Epithecium light to dark olivaceous brown, 10–20 µm tall, K–, N–; hymenium colourless, 50–65 µm tall, I_{Lugol}+ orange-red, KI_{Lugol}+ slightly blue, $I_{Meltzer}$–; hypothecium colourless to pale brown, 10–15 µm tall. Hamathecium of paraphysoids, abundant, septate, branched and anastomosed, 2–2.5 µm wide; markedly swollen apices, olivaceous brown, to 4–5.5 µm wide. Asci broadly clavate, short-stalked, bitunicate in structure, 8-spored, inner part I_{Lugol}+ red, KI_{Lugol}–, without a KI_{Lugol}+ blue apical ring, (23–)27–38 × 14–18(–22) µm. Ascospores irregularly arranged in the asci, ellipsoid, hyaline, 1-septate, rounded to somewhat broadly pointed at the apices, slightly constricted at the septa, the upper cell slightly larger than the lower one, with 1–3 oil droplets at times and a gelatinous sheath, the gelatinous sheath I_{Lugol}+ red, (10–)11.5–14 × 4–5.5(–6.5) µm (*n* = 36), l/b = (1.8–)2.3–3.0(–3.5), all measurements including the closely adhering sheath. Conidiomata not observed.

Ecology and distribution: Commensalistic or weakly parasitic on the thalli of *Dimelaena oreina* as slight bleaching occurs on the infected areoles of the host thalli, especially in the later infection stage. The new species is known from two localities in central and eastern Turkey. As the host species has a wide distribution in the Northern Hemisphere, the species should be sought for elsewhere.

Observations: *Arthonia hawksworthii* is most similar to *A. gelidae* R.Sant., which was described by Santesson (1986) on the thallus of *Placopsis gelida* from Sweden. Besides the different hosts, *A. hawksworthii* differs from *A. gelidae* in that it has ascospores with a gelatinous sheath that stains red in $I_{Lugol,}$ and has an epithecium that is light to dark brown with an olivaceous tinge in KOH.

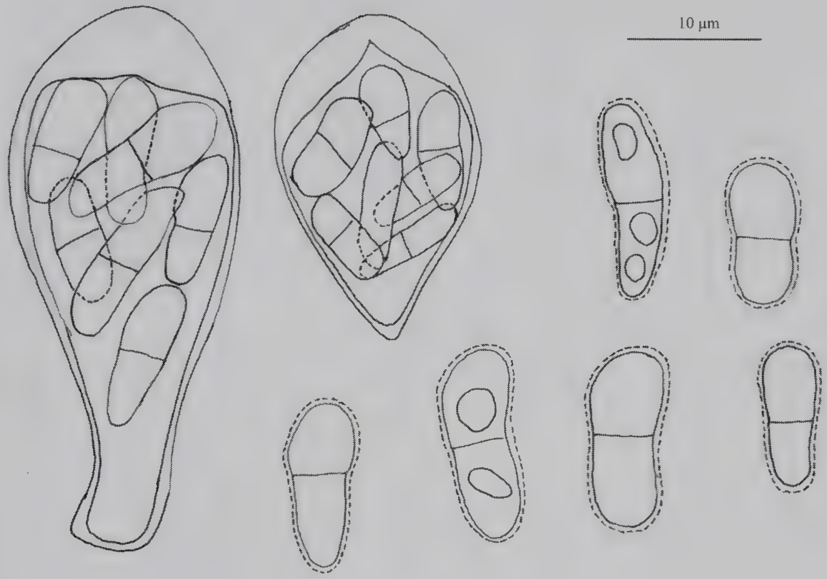

Fig. 1. ***Arthonia hawksworthii*** (holotype). A, mature asci. B, Six ascospore outlines showing the gelatinous sheath, two of the ascospores including oil droplets. Scale = 10 μm.

The lichenicolous species of *Arthonia* characterized by positive iodine reactions of ascospore sheaths include *A. pseudopegraphina* Matzer, *A. intermedia* Matzer, *A. santessonii* Matzer, *A. diploiciae* Calat. & Diederich, *A. almquistii* Vain., *A. amylospora* Almq., *A. intexta* Almq. and *A. obscurior* Triebel (Grube & Matzer 1997). The hymenium is also I_{Lugol}+ dark blue and KI_{Lugol}+ red in *A. gelidae* (Santesson 1986), but I_{Lugol}+ only slightly blue and KI_{Lugol}+ orange-red in *A. hawksworthii*. *A. epimela* Norman, a lichenicolous species on *Amandinea punctata,* has larger ascomata than *A. hawksworthii* [0.1–0.4 mm diam vs. 0.4–0.6 mm diam], narrower ascospores [3.5–4.5 μm vs. 4–5.5(–6.5) μm] and a brown hypothecium (Almquist 1880, Clauzade et al. 1989). *A. epiphyscia* Nyl., which is commensalistic or weakly parasitic on *Physcia* species, has a dark reddish K+ olivaceous hypothecium (Coppins 1992). *A. phaeophysciae* Grube & Matzer, a parasite causing considerable damage to *Phaeophyscia* thalli, has asci with a KI_{Lugol}+ blue apical ring and a K+ greyish hypothecium (Grube & Matzer 1997). *A. caerulescens* (Almq.) R.Sant., a lichenicolous species confined to the apothecia of *Lecanora varia*, has shorter ascospores [10–12 μm vs. (10–)11.5–14 μm] (Almquist 1880). The characters distinguishing the similar species are provided in Table 1.

Table 1. Characters distinguishing *Arthonia epimela*, *A. epiphyscia*, *A. gelidae*, *A. hawksworthii* and *A. phaeophysciae*.

Character	*A. epimela*	*A. epiphyscia*	*A. gelidae*	*A. hawksworthii*	*A. phaeophysciae*
Ascomata size	0.4–0.6 mm	0.1–0.35 mm	0.2–0.5 mm	0.1–0.4 mm	0.12–0.25 mm
Hymenial gel	I_{Lugol} + red	I_{Lugol} + red	I_{Lugol} + red	I_{Lugol} + orange-red	I_{Lugol} + red
Epithecium	brown	brown, K ± olivaceous	dark brown	light to dark olivaceous brown	pale olive brown
Hypothecium	brown	hyaline to dark reddish brown	hyaline	hyaline to pale brown	hyaline to pale brown
Asci (µm)	30–35 × 13–16	24–32 × 13–15	35–45 × 14–18	(23–)27–38 × 14–18(–22)	35–45 × 16–20
Ascospores (µm)	9–13 × 3.5–4.5	10–14 × (3–)3.5–5	11.5–16 × (4–)5–6	(10–)11.5–14 × 4–5.5(–6.5)	12–14 × 4–6
Gelatinous sheath	I_{Lugol} –	I_{Lugol} –	I_{Lugol} –	I_{Lugol} + red	I_{Lugol} –
Host	*Amandinea punctata*	*Physcia* spp.	*Placopsis gelida*	*Dimelaena oreina*	*Phaeophyscia* spp.
References	Almquist (1880), Clauzade et al. (1989)	Coppins (1992) Note: measurements of asci were taken personally from a collection on *Physcia dubia* from Turkey.	Santesson (1986), Coppins (1992)	Present paper	Grube & Matzer (1997)

ADDITIONAL SPECIMENS EXAMINED: Turkey, Kahramanmaraş, Narlı District, near the highway to Gaziantep, 37°19'N, 37°08'E, alt. 600 m, on areoles of *Dimelaena oreina* on siliceous rocks, 7 July 2004, leg. M. G. Halıcı 0.1387 (herbarium at the Erciyes University).

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Corticolous lichens of the city of Giresun with descriptions of four species new to Turkey

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Abstract — Corticolous lichens were studied in the city of Giresun (Turkey). The survey yielded 54 species, all *Ascomycota,* among which *Anisomeridium polypori, Lecanora compallens, Lepraria umbricola* and *Schismatomma decolorans* are new to Turkey. *Lecanora compallens* is new to Asia while *Anisomeridium polypori* and *Lepraria umbricola* are reported for the second time from Asia. Data and accompanying species are given for all taxa while short descriptions are also presented for the four species that are new to Turkey.

Keywords — biodiversity, flora

Introduction

Studies on the lichen flora of Turkey are not as extensive as elsewhere. Last year, many new lichen taxa were reported for Turkey (Doğru & Güvenç 2007, Yazici & Aptroot 2007, Yazici et al. 2007a,b). Although there was some previous lichenological research in the Black Sea Coast city of Giresun (Aslan & Yazıcı 2006, Duman & Yurdakulol 2007, Kınalıoğlu 2006), several regions in Giresun remained still unexplored. The present paper provides information on corticolous lichens in the city center of Giresun, Turkey.

Materials and methods

The corticolous lichen samples were collected from deciduous trees from 01–30 October 2007 in the city of Giresun (Turkey). The study area is situated at 40°54'N, 38°23'E. Air-dried lichen samples were observed and studied using stereo and light microscopes. Secondary metabolites were identified by the usual spot tests (Poelt 1974, Purvis et al. 1992, Herk & Aptroot 1999, Wirth 1995, Zedda 2000).

Results

A lichen survey of the city of Giresun yielded 54 species, all *Ascomycota,* among which *Anisomeridium polypori, Lecanora compallens, Lepraria umbricola* and *Schismatomma decolorans* are new to Turkey. *Lecanora compallens* is new to Asia, while *Anisomeridium polypori* and *Lepraria umbricola* are reported here for the second time from Asia. Additionally, *Caloplaca flavocitrina* and *Phaeophyscia chloantha* represent second reports for Turkey. Collection data and information accompanying species are given for all lichen taxa, and short descriptions are also presented for the four species new to Turkey. The lichen taxa are listed alphabetically.

Amandinea punctata (Hoffm.) Coppins & Scheid.

> City center and Giresun Castle, on *Fraxinus* sp., *Albizia julibrissin*, main roadside on *Robinia pseudoacacia*, accompanying species: *Caloplaca obscurella, Candelariella reflexa, Hyperphyscia adglutinata, Lecanora compallens, Phaeophyscia orbicularis* and *Rinodina gennarii.* Yazici 1304.

Anisomeridium polypori (Ellis & Everh.) M.E. Barr

Thallus mostly inconspicuous, effuse, grey or pale grey to green. Perithecia 0.15-0.25 mm diam., subconical to ± globose, initially immersed; upper wall with a slightly converted involucrellum. Asci 5-75(-85) × 11-16 μm, cylindric-clavate. Ascospores (13-)15-20(-22) × (3.5-)4.5-5 μm, 1-3 septate, clavate-fusiform, Pycnidia black, of two types, first one: 100–150 μm diam., ± sessile, conical, colourless, with ellipsoid or ovoid macroconidia, (3-)3.5-4.5(-5) × 1.8-2 μm, extruded as a white cirrus, in which the conidia are bound by a gelatinous matrix; second one: 50–100 μm diam., ± immersed, globose, with rod-shaped to narrowly ellipsoid microconidia, 2-3 × 1-1.3 μm. Photobiont *Trentepohlia.*

Known throughout Europe, Australia, Canada, China, Costa Rica, Japan, North America, Russia, Thailand. A second report for Asia.

> Giresun: Center; Giresun Castle, 120 m, 40°54'57" N, 38°23'24" E, on *Fraxinus* sp., unpolluted area, accompanying species: *Gyalecta truncigena.* 10 October 2007.Yazici 1318.

Ecology of the survey area–The area has a typical oceanic climate with a mild and high precipitation prevailing along the coast. It is at 120 m elevation and at 150 m distance from the Black Sea. Annual temperature is 14.2°C in the city of Giresun while annual precipitation is 1305 mm. On average there are 184 rainy days, 6 snowy days and 11 snow-covered days. Winters are more intense with longer snow cover, while the summers are cool. Rainy days occur in every season, the most rainy days however in autumn and winter. The well-lit site, which is occasionally exposed to strong wind in winter, is rich compared to the forest. It has tree communities with *Albizia julibrissin, Robinia pseudoacacia, Salix* sp. and *Platanus orientalis.*

Remarks—*Anisomeridium polypori* is a cosmopolitan species frequent suboceanic and mild-temperate region. Generally it especially grows on rough bark of *Sambucus, Populus,* and *Ulmus* by rivers and brooks in humid woodland, rarely on shaded rock, and is sometimes common in polluted areas. *Anisomeridium polypori* is very similar to *A. biforme*, but it has a less conspicuous thallus, smaller perithecia with a thinner upper wall, and longer and narrower ascospores with often 1–3 septa, but is especially characterized by the long-ostiolate pycnidia with agglutinating conidia.

Arthonia dispersa (Schrad.) Nyl.

City center, on *Acer* sp., *Fraxinus* sp., *Ficus* sp.; Giresun Castle, on *Albizia julibrissin, Ficus* sp., *Fraxinus* sp., and *Salix* sp., accompanying species: *Naetrocymbe punctiformis.* Yazici 1323.

Arthonia radiata (Pers.) Ach.

Giresun Castle, 120 m, on *Robinia pseudoacacia* and *Fraxinus* sp. Yazici 1322.

Bacidia laurocerasi (Duby) Zahlbr.

City center, on *Ligustrum* sp., *Betula* sp.; Giresun Castle, 120 m, on *Fraxinus* sp. Yazici 1315.

Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr.

City center and main roadside on *Robinia pseudoacacia,* accompanying species: *Physcia adscendens, P. tenella* and *Xanthoria parietina.* Yazici 1327.

Caloplaca cerinella (Nyl.) Flagey

City center, on *Acer* sp., accompanying species: *Hyperphyscia adglutinata, Lecania fuscella* and *Lecidella achristotera.* Yazici 1301.

Caloplaca citrina (Hoffm.) Th. Fr.

City center, park, on *Salix* sp., *Platanus orientalis, Robinia pseudoacacia,* and *Ligustrum* sp., main roadside on *Fraxinus* sp. and *Robinia pseudoacacia*; Giresun Castle, on *Albizia julibrissin,* accompanying species: *Hyperphyscia adglutinata, Phaeophyscia orbicularis, Physcia tenella, P. adscendens* and *Xanthoria parietina.* Yazici 1328.

Caloplaca flavocitrina (Nyl.) H. Olivier

City center and main roadside, on *Robinia pseudoacacia,* accompanying species: *Candelariella reflexa, Lecanora dispersa* and *Phaeophyscia orbicularis.* Found for the second time in Turkey. Yazici 1305.

Caloplaca holocarpa (Hoffm.) A.E. Wade

City center, on *Acer* sp. and *Robinia pseudoacacia,* accompanying species: *Caloplaca cerina, Hyperphyscia adglutinata, Lecania cyrtella, Lecanora chlarotera, L. dispersa, Lecidella elaeochroma, Physcia adscendens* and *P. tenella.* Yazici 1307.

Caloplaca obscurella (J. Lahm ex Körb.) Th. Fr.

City center, on *Robinia pseudoacacia,* accompanying species: *Amandinea punctata, Hyperphyscia adglutinata, Phaeophyscia orbicularis* and *Rinodina gennarii.* Yazici 1303.

Candelaria concolor (Dicks.) Stein

City center and main roadside, on *Fraxinus* sp., accompanying species: *Hyperphyscia adglutinata, Lecanora dispersa, Physcia adscendens, P. tenella* and *Xanthoria parietina.* Yazici 1329.

Candelariella aurella (Hoffm.) Zahlbr.

City center and main roadside, on *Robinia pseudoacacia*, accompanying species: *Lecanora dispersa.* Yazici 1330.

Candelariella reflexa (Nyl.) Lettau

City center, on *Robinia pseudoacacia* and *Fraxinus* sp., accompanying species: *Amandinea punctata, Caloplaca flavocitrina, Lecania cyrtella, Lecanora compallens, L. dispersa* and *Phaeophyscia orbicularis.* Yazici 1302.

Chrysothrix candelaris (L.) J.R. Laundon

Giresun Castle, 120 m, on *Albizia julibrissin.*Yazici 1331.

Evernia prunastri (L.) Ach.

Giresun Castle, 120m, on *Albizia julibrissin,* accompanying species: *Flavoparmelia caperata* and *Pseudevernia furfuracea.* Yazici 1332.

Flavoparmelia caperata (L.) Hale

City center, 5 m, on *Pyrus* sp., main roadside; Giresun Castle, 120 m, on *Robinia pseudoacacia* and *Albizia julibrissin*, accompanying species: *Punctelia subrudecta, Parmelia sulcata, Evernia prunastri* and *Melanelixia fuliginosa.* Yazici 1334.

Graphis scripta (L.) Ach.

Giresun Castle, 120 m, on *Albizia julibrissin*. Yazici 1321.

Gyalecta truncigena (Ach.) Hepp

Giresun Castle, on *Fraxinus* sp. accompanying species: *Anisomeridium polypori.* Yazici 1318.

Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt

City center and along the main roadside 5–20 m, on *Tilia* sp., *Acer* sp., *Salix* sp., *Robinia pseudoacacia, Ligustrum* sp., *Cercis siliquastrum* and *Fraxinus* sp., also Giresun Castle 120 m, on *Albizia julibrissin* and *Platanus orientalis*, accompanying species: *Amandinea punctata, Caloplaca cerinella, C. holocarpa, C. obscurella, Lecania fuscella, Lecidella achristotera, Phaeophyscia chloantha, P. orbicularis* and *Rinodina gennarii.* Yazici 1303.

Hypogymnia physodes (L.) Nyl.

Giresun Castle, 120 m, on *Albizia julibrissin*, accompanying species: *Hypogymnia tubulosa*, Yazici 1333.

Hypogymnia tubulosa (Schaer.) Hav.

Giresun Castle, 120 m, on *Albizia julibrissin,* accompanying species: *Hypogymnia physodes.* Yazici 1335.

Lecania cyrtella (Ach.) Th. Fr.

City center, 40 m, on *Acer* sp., main roadside, on *Robinia pseudoacacia*, accompanying species: *Candelariella reflexa* and *Lecanora umbrina.* Yazici 1316.

Lecania fuscella (Schaer.) A. Massal.

City center, 40 m, on *Acer* sp., main roadside, on *Robinia pseudoacacia*, accompanying species: *Caloplaca holocarpa, C. cerinella, Hyperphyscia adglutinata, Lecidella achristotera, Physcia adscendens* and *Lecanora dispersa.* Yazici 1307.

Lecania naegelii (Hepp) Diederich & Van den Boom

City center, 40 m, on *Acer* sp., accompanying species: *Lecania cyrtella.* Yazici 1336.

Lecanora argentata (Ach.) Malme

City center, 5 m, on *Salix* sp.; Giresun Castle, 120 m, on *Albizia julibrissin, Castanea* sp., and *Acer* sp., main roadside, 5 m, on *Ficus* sp., accompanying species: *Lecidella achristotera.* Yazici 1310.

Lecanora campestris (Schaer.) Hue

City center, 5 m, on *Ficus* sp. Yazici 1337.

Lecanora chlarotera Nyl.

City center, 5m, on *Salix* sp. and *Acer* sp., accompanying species: *Caloplaca holocarpa.* Yazici 1317.

Lecanora compallens Herk & Aptroot

Thallus corticolous, usually 1–3 cm diam., continuous; margin whitish grey, immersed and shiny, usually with low, glaucous grey warts of 0.1–0.2 mm diam., without hypothallus; medulla below soredia 0.1–0.3 mm thick, white. Soralia always present, usually covering most of the thallus, except for a marginal zone of *c.* 1 mm., 0.1–0.3 mm punctiform openings, soon uprising and aggregating into irregular patches. Soredia granular, in a dense mass, 15–30 in diam., yellowish to slightly mint–green, contrasting in colour with the thallus. Apothecia and pycnidia unknown. Thallus C– , P– , K–, UV–; soredia C– , P–, K+ yellowish to yellowish brown usnic acid and zeorin found with TLC (Herk & Aptroot 1999).

Lecanora compallens, previously known from Western Europe, most commonly occurs on medium-aged trees, mainly on the flat surfaces of the ridges, and also on acid as well as neutral bark. Usually on the west side of exposed wayside trees, especially *Quercus, Fraxinus, Populus, Salix, Sorbus, Tilia, Ulmus* and *Sambucus.*

Known from Belgium, Denmark, England, France, Germany, Lithuania, Luxembourg, Poland, the Netherlands, and Ukraine. New to Asia.

Giresun: Center: Giresun Castle, 40°545'7" N, 38°23'24" E, on *Albizia julibrissin*, 120 m, accompanying species: *Amandinea punctata, Phaeophyscia orbicularis* and *Candelariella reflexa.* 10 October 2007. Yazici 1302.

Ecology of the survey area–See *Anisomeridium polypori.*

Remarks — *Lecanora compallens* is very similar to *L. expallens* and *L. barkmaniana,* but *L. compallens* is distinguished from *L. expallens* in always having a non-sorediate thallus margin of 1 mm with low glaucous grey corticate warts. Furthermore, *L. expallens* has usually excavate soralia and a more yellowish, never mint-green, colour, and sometimes a black hypothallus is present. *L. expallens* can be easily separated by the C +orange reaction due to the presence of thiophanic acid. *L. barkmaniana* and *L. compallens* have microscopically identical soredia, but *L. compallens* differs by the yellowish tinge of the soredia and by a much thinner, often mostly immersed thallus, and *L. barkmaniana* reacts Pd+ yellow.

Lecanora dispersa (Pers.) Sommerf.

City center, on *Fraxinus* sp., *Pyrus* sp., and *Robinia pseudoacacia,* main roadside, on *Acer* sp., *Fraxinus* sp., *Salix* sp., and *Robinia pseudoacacia*, accompanying species: *Caloplaca flavocitrina, C. holocarpa, Candelariella aurella, C. reflexa, Lecania fuscella, Physcia adscendens, Phaeophyscia orbicularis* and *Rinodina gennarii.* Yazici 1309.

Lecanora umbrina (Ach.) A. Massal.

City center and main roadside, 2 m, on *Robinia pseudoacacia* and *Acer* sp., accompanying species: *Lecania cyrtella.* Yazici 1316.

Lecidella achristotera (Nyl.) Hertel & Leuckert

City center and main roadside, on *Acer* sp., *Ficus* sp., *Fraxinus* sp., *Pyrus* sp.; Giresun Castle, 120 m, on *Robinia pseudoacacia*, accompanying species: *Caloplaca cerinella, Hyperphyscia adglutinata, Lecania fuscella, Lecanora argentata* and *Lecidella elaeochroma.* Yazici 1301.

Lecidella elaeochroma (Ach.) M. Choisy

City center, 10 m, on *Acer* sp., *Ligustrum* sp., and *Prunus* sp., main roadside, 2 m, on *Ficus* sp. and *Robinia pseudoacacia*; Giresun Castle, 120 m, on *Albizia julibrissin*, *Laurus* sp., and *Robinia pseudoacacia,* accompanying species: *Caloplaca holocarpa* and *Xanthoria parietina.* Yazici 1338.

Lepraria incana (L.) Ach.

Giresun Castle, 120 m, on *Albizia julibrissin*. Yazici 1339.

Lepraria umbricola Tønsberg

Thallus leprose, powdery appearance, diffuse, deep greenish or whitish greyish, sometimes weft–like, usually thin, rarely thick, cortex absent, lacking marginal lobes and without medulla, protected from direct rain in shaded sites; soredia abundant to scattered, forming small granules, granules to 0.1 mm diam and short projecting hyphae frequent. Thamnolic acid present, thallus K + deep yellow, C–, KC–, P + deep orange.

Lepraria umbricola grows on bark, rock, mosses, soil, mostly acidic substrata; shaded, sheltered, humid, sometimes extremely shaded.

Known throughout Europe, Africa, Australia, Canada, Colombia, North America, Pacific Northwest, Russia, and even (probably incorrectly) reported from Thailand. Found for the second time in Asia.

Giresun: Center: Giresun Castle, 40°545'7" N, 38°23'24" E, on *Albizia julibrissin*, 120 m. 10 October 2007. Yazici 1308.

Ecology of the survey area—See *Anisomeridium polypori.*

Remarks–*Lepraria umbricola* is an oceanic to warm–temperate species, found on sheltered mossy siliceous rocks and terricolous mosses, sometimes on basal parts of old trunks on shaded sandy soil. *Lepraria umbricola* is somewhat similar to *L. incana* and *L. eburnea,* but *L. incana* has a more conspicuous medulla. Additionally *L. incana* has divaricatic acid and zeorine while *L. umbricola* has thamnolic acid.

Lepraria vouauxii (Hue) R.C. Harris

City center, 20 m, on *Tilia* sp., main roadside, 2 m, on *Magnolia* sp. Yazici 1313.

Melanelixia fuliginosa (Fr. ex Duby) O. Blanco et al.

Giresun Castle, 120 m, on *Albizia julibrissin*, accompanying species: *Flavoparmelia caperata* and *Parmelia sulcata.* Yazici 1340.

Melanelixia subaurifera (Nyl.) O. Blanco et al.

Giresun Castle, 120 m, on *Albizia julibrissin.* Yazici 1319.

Naetrocymbe punctiformis (Pers.) R.C. Harris

Giresun Castle, 120 m, on *Albizia julibrissin*, *Fraxinus* sp., and *Prunus* sp., accompanying species: *Arthonia dispersa.* Yazici 1320.

Opegrapha atra Pers.

City center, 50 m, on *Corylus* sp., *Quercus* sp.; Giresun Castle, 120 m, on *Acer* sp., *Corylus* sp., and *Fraxinus* sp. Yazici 1325.

Opegrapha varia Pers.

City center, 2 m, on *Acer* sp.; Giresun Castle; 120 m, on *Acer* sp. Yazici 1324.

Opegrapha vulgata (Ach.) Ach.

City center, 10 m, on Morus sp. Yazici 1326.

Parmelia sulcata Taylor

City center, main roadside, 2 m, on *Fraxinus* sp.; Giresun Castle, 120 m, on *Albizia julibrissin*, accompanying species: *Flavoparmelia caperata* and *Melanelixia fuliginosa.* Yazici 1341.

Pertusaria amara (Ach.) Nyl.

Giresun Castle, 120 m, on *Albizia julibrissin.* Yazici 1342.

Phaeophyscia chloantha (Ach.) Moberg

City center, main roadside, 2 m, on *Magnolia* sp. and *Robinia pseudoacacia*; Giresun Castle, 120 m, on *Albizia julibrissin*, accompanying species: *Hyperphyscia adglutinata* and *Phaeophyscia orbicularis*. Found for the second time in Turkey. Yazici 1311.

Phaeophyscia orbicularis (Neck.) Moberg

City center, 5–50 m, on *Acer* sp., *Ligustrum* sp., main roadside, 2 m, *on Robinia pseudoacacia, Acer* sp., *Fraxinus* sp., and *Populus* sp.; Giresun castle, 120 m, on *Albizia julibrissin*, accompanying species: *Amandinea punctata, Caloplaca flavocitrina, C. obscurella, Candelariella reflexa, Hyperphyscia adglutinata, Lecanora compallens, L. dispersa, Phaeophyscia chloantha, Physcia tenella, Rinodina gennarii* and *Xanthoria parietina*. Yazici 1302.

Physcia adscendens (Th. Fr.) H. Olivier

City center, 5–50 m, on *Acer* sp., *Fraxinus* sp., *Ligustrum* sp., *Populus* sp, and *Robinia pseudoacacia*; Giresun Castle, 120 m, on *Albizia julibrissin, Fraxinus* sp., *Acer* sp., accompanying species: *Caloplaca cerina, C. holocarpa, Phaeophyscia orbicularis* and *Physcia tenella*. Yazici 1307.

Physcia tenella (Scop.) DC.

City center, 10 m, on *Ligustrum* sp., main roadside, 2m, on *Robinia pseudoacacia* and *Populus* sp., accompanying species: *Caloplaca cerina* and *Physcia adscendens*. Yazici 1343.

Punctelia subrudecta (Nyl.) Krog

City center, 2 m, on *Pyrus* sp., accompanying species: *Flavoparmelia caperata*. Yazici 1344.

Pseudevernia furfuracea (L.) Zopf

Giresun Castle, 120 m, on *Albizia julibrissin*, accompanying species: *Evernia prunastri* and *Flavoparmelia caperata*. Yazici 1345.

Ramalina farinacea (L.) Ach.

Giresun Castle, 120 m, on *Albizia julibrissin*. Yazici 1346.

Rinodina gennarii Bagl.

City center and main roadside, 2 m, on *Robinia pseudoacacia*, accompanying species: *Amandinea punctata, Caloplaca obscurella, Hyperphyscia adglutinata, Lecanora dispersa* and *Phaeophyscia orbicularis*. Yazici 1306.

Schismatomma decolorans (Turner & Borrer ex Sm.) Clauzade & Vězda

Thallus crustose, sorediate, thin, to 3 cm in diam., attached to the substrate with the whole lower surface or with raised, free margins lilac to pinkish grey, mauve-grey to brown, developing concolorous or slightly paler sorediate patches which usually cover the whole surface of mature specimens, giving a leprose appearance, becoming grey to brownish grey in the herbarium, ± rimose–cracked; a grey-black prothallus often ± present; with entire margins and continuous or more ore less fissured and divided into areoles, flat and mainly parallel to the substrate; upper side clearly different from the underside, not much swollen when wet and usually not wrinkled when dry; photobiont *Trentepohlia,* algal cells and hyphae surrounded by air. Soredia puntiform, 0.2–0.8(–1) mm daim., ± concolorous discrete or sparingly confluent, often covering relatively large areas, mauve-grey to pale lilac-grey, occasionaly with an ochry tinge. Apothecia and pycnidia unknown. Thallus K–, KC–, C–, P–, UV–.

Known throughout Europe (e.g. eastern part of the Italian peninsula, England, France, Germany, Northern Ireland, Spain, Sweden, The Netherlands), Algeria, Cyprus, Iran, North America, Syria, Tanzania. Reported for the second time from Asia.

> Giresun: Center; Giresun Castle, 40°545'7" N, 38°23'24" E, on *Albizia julibrissin,* 120 m, 10 October 2007. Yazici 1314.

ECOLOGY OF THE SURVEY AREA–See *Anisomeridium polypori.*

REMARKS-*Schismatomma decolorans* is a mild–temperate and suboceanic species, most commonly growing in sheltered and shaded recesses of old rough-barked deciduous trees in wayside and woodland sites, rarely on dry vertical rocks or walls, exposed mineral-rich rock stones and steeply inclined faces in lichen–poor communities, tolerant of relatively high levels of agricultural chemicals and fertilizers.

Xanthoria parietina (L.) Th. Fr.

> City center, 2–50 m and main roadside, 2 m, on *Ligustrum* sp., *Acer* sp., *Elaeagnus* sp., *Ficus* sp., *Fraxinus* sp., *Platanus orientalis*, *Pyrus* sp., *Robinia pseudoacacia,* and *Salix* sp., accompanying species: *Caloplaca cerina, Candelaria concolor, Lecidella elaeochroma, Physcia adscendens* and *Phaeophyscia orbicularis.* Yazici 1312.

Discussion

The population of Giresun city at the Eastern Black Sea coast is approximately 100,000, according to the census in 2007. The average elevation of the city center is 50 m. Giresun Castle, which is situated in the north of the city, lies at 120 m elevation and at 150 m distance from the Black Sea, in an unpolluted area. Until 2003, sulphur dioxide measurements from the area are not reliable, and these measurements were not performed in 2003–2006. From January 2007 onwards, more reliable measurements have been made. According to these, the annual average sulphur dioxide concentration in the atmosphere is approximately 50µg/m^3 in 2007 (Türkiye Cumhuriyeti Çevre ve Orman Bakanlığı 2007).

In total 33 lichen species, including the four new to Turkey, were found in Giresun Castle, while 30 species were present along the main roads; 36 taxa in the other parts of the city center. All species were found on 20 different deciduous tree species, such as *Acer* sp., *Albizia julibrissin, Ficus* sp., *Fraxinus* sp., *Ligustrum* sp., *Robinia pseudoacacia* and *Salix* sp.: 26 species were found on *Albizia julibrissin,* 23 on *Robinia pseudoacacia,* 18 on *Acer* sp. and 18 on *Fraxinus* sp. The area Giresun Castle is apparently an unpolluted area since its 33 lichen taxa include sensitive species such as *Evernia prunastri, Pseudevernia furfuracea, Ramalina farinacea, Hypogymnia physodes* and *H. tubulosa*. On the other hand, it is remarkable that still 30 lichen species have been found along the main roads, although these sites are exposed to heavy metals from motor vehicles and other forms of pollution.

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Balaniopsis triangularis sp. nov. from indoor environments

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Abstract — A new species of *Balaniopsis* is described and illustrated from specimens collected during indoor mold inspections in North America.

Key Words — hyphomycete, mitosporic fungi, taxonomy, type

Introduction

In recent years, unidentified triangular spores that appeared to be conidia were recorded by the authors on tape lifts and in spore traps. Occasionally, conidiogenous cells and parts of conidiophore stipes were also seen. On rare occasions, the orientation of the spores relative to the conidiogenous cells and conidiophores was seen. Although the organism has not been successfully grown in culture, a specimen recently collected from conifer wood over a crawl space in a building in Vancouver, Canada, allowed the authors to characterize the species as *Balaniopsis triangularis* anam. sp. nov..

Materials and methods

Conidiophores and conidia of the fungus were mounted in lacto-fuchsin (0.1 g acid fuchsin, 100 ml 85% lactic acid) (Carmichael 1955). Microscopic

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observations were made using Nomarski differential interference contrast optics. Herbarium acronyms follow Index Herbariorum (Holmgren & Holmgren 1998).

Results

Balaniopsis triangularis D.W. Li & W.B. Kendr., **anam. sp. nov.** Figures 1–13
MycoBank MB 511446.

> *Conidiophora macronemata, determinata, erecta, non-ramosa vel ramosa, recta vel flexuosa, lutea, septata, interdum >200 µm longa et 0.7–2 µm crassa apud basis, 2.9–3.4 µm apud apicem. Cellulae conidiogenae polyblasticae, laeves, cupulatae vel obconicae. Conidia unicellularia, triangularia, non catenata, laevia, lutea, 6.0–7.4 × 6.4–8.6 × 3.0–3.6 µm. Teleomorphosis ignota.*
>
> *Holotypus BPI 878719, Isotypus DAOM 239847 superficie in ligno domi, Vancouver, Canada leg. S. Campbell,. 28 iv. 2008.*
>
> Etymology: referring to the triangular shape of the conidia.

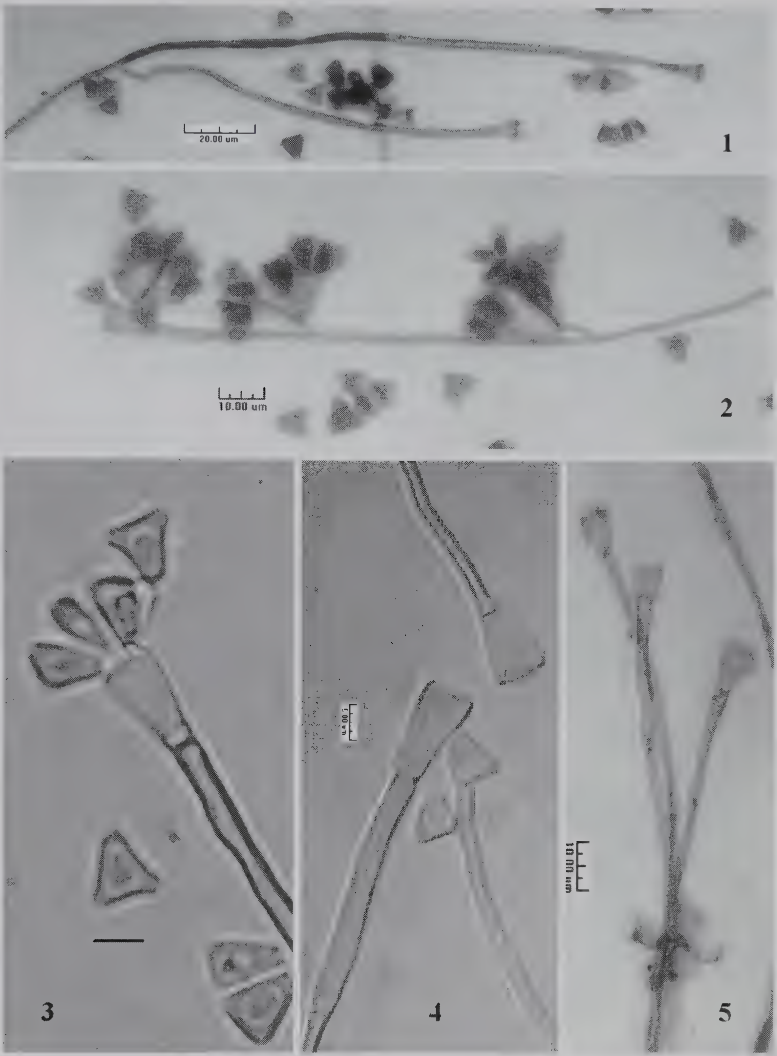
Conidiophores solitary, determinate, erect, unbranched or branched, straight or flexuous, yellowish, smooth, septate, thin-walled when young, becoming thick-walled at maturity, sometimes exceeding 200 µm in length, 0.7–2 µm wide at base, widening to 2.9–3.4 µm at the apex.

Conidiogenous cells terminal, subapical or lateral, obovoid first, becoming cupulate or obconic (champagne flute-shaped) after conidia have been released, due to partial collapse of apical portion, smooth, yellowish, terminal, solitary, (6.8–) 9.3–14.7 (–16.6) (mean = 12 ± 2.7, n=17) long, (5.6–) 6.3–7.9 (–8.6) (mean = 7.1 ± 0.8 µm, n=17) wide at the widest point, narrowing to the proximal end (2.6–) 2.7–3.3 (–3.8) (mean = 3.0 ± 0.3 µm, n=17), subapical or lateral in whorls of 3-5, (7.8–) 8.3–10.5 (–12.6) (mean = 9.4 ± 1.1, n = 19) × (5.1–) 6.6–8.4 (–8.9) (mean = 7.5 ± 0.9, n = 19). Developing 6-8 conidia polyblastically and perhaps synchronously in the apical area.

Conidia 1-celled (amerosporous), cuneiform (wedge-shaped) when young, triangular at maturity, yellowish, smooth-walled, later becoming thick-walled, (5.6-) 6.0–7.4 (-8.8) (mean = 6.7 ± 0.7, n = 31) × (5.5-) 6.4–8.6 (-9.6) µm (mean = 7.5 ± 1.1 µm, n = 31) × (2.7-) 3.0–3.6 (-4.2) µm (mean = 3.3 ± 0.3 µm, n = 31) µm, side wall about 1 µm thick, at the three corners 2–2.4 µm thick. Conidial secession is rhexolytic. The remnants of separating cell walls persist at the base of some conidia (Figure 7). The corners of the released conidia may appear rounded or, more commonly, truncate. The truncate condition probably indicates some minor collapse of the outer wall subsequent to drying.

Teleomorph unknown.

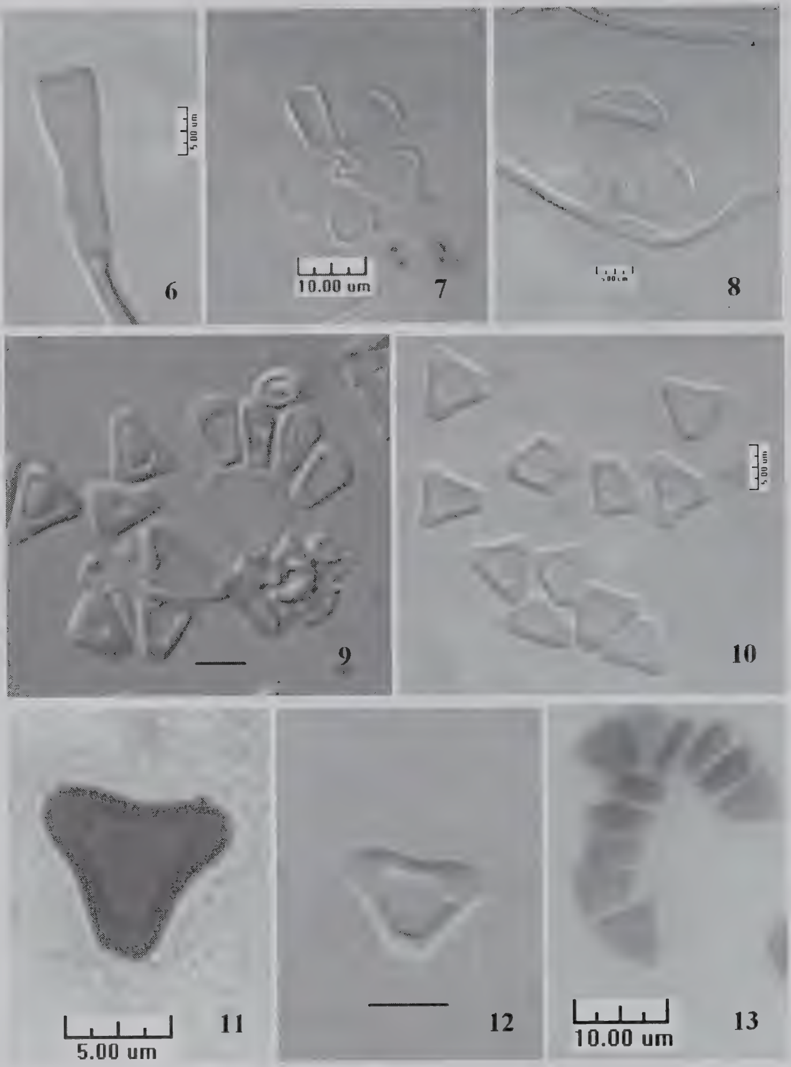
Known Geographical distribution: British Columbia, Canada; California and New York, USA.



Figures 1-5. *Balaniopsis triangularis*. 1. Branched conidiophore, conidiogenous cells, and conidia. 2. Conidiophore with terminal and lateral conidiogenous cells, and conidia. 3, 4. Terminal conidiogenous cells. 5. Terminal and lateral conidiogenous cells. 5. Conidiogenous cells. Scale bars: 1 = 20 µm, 2, 5 = 10 µm, 3-4 = 5 µm.

HABITAT: saprotrophic on damp wood and plywood.

SPECIMENS EXAMINED: CANADA, British Columbia, Vancouver, Marine Drive, crawl space of building, 28 April 2008, Shannon Campbell, holotype (BPI 878719), isotype (DAOM 239847); UNITED STATES, New York, Livingston, 7 March 2007, anonymous, (BPI 878411).



Figures 6-13. *Balaniopsis triangularis*. 6. Terminal conidiogenous cells. 7-8. Lateral conidiogenous cells. 9. Lateral conidiogenous cells bearing conidia in face- and side-view 10-12. Conidia in face-view. 13. Conidia in face- and side-view.

Scale bars: 6, 8-12 = 5 µm, 7, 13 = 10 µm.

Discussion

The genus *Balaniopsis* P.M. Kirk was proposed by Kirk (1985) with a single species, *Balaniopsis africana* (Kiffer) P.M. Kirk (≡ *Balanium africanum* Kiffer). His establishment of the new genus was based on three major characters:

1) rhexolytic conidial secession, 2) percurrent extension, and 3) conidia in short, branched chains on unbranched conidiophores. However, Whitton et al. (2002) emended the generic description, reinterpreting the conidiogenous cells and adding a second species. There were significant differences between Kiffer's specimen referred to as the holotype by Kirk (1985) and Kirk's generic and specific descriptions, which were based on the specimen he collected in Kenya. The key characters of the revised circumscription of *Balaniopsis* include rhexolytic conidial secession, sometimes with percurrent extension of the conidiogenous cell, and unbranched or branched conidiophores. The description of conidia as occurring in short branched chains was not included in the revised circumscription because the entity defined by Kirk (1985) as a basal conidium was interpreted by Ellis (1976) and Whitton et al. (2002) as a conidiogenous cell, which implied that the conidia were produced singly and probably synchronously.

Whitton et al. (2002) clarified that the holotype and Kirk's specimen are two different species. *Balanium africanum,* described and illustrated by Kiffer (1973), has a light-dark-light pattern of pigmentation of the conidiophore cells, triangular conidia (9–12 × 7–10 μm), and longer separating cells, while Kirk's specimen has concolourous conidiophores, broadly obovoid conidia (12.8–14.5 × 9.5–11 μm), and much shorter separating cells. The name *Balaniopsis africana* must be applied to Kiffer's collection. The specimen collected by Kirk is not conspecific with that of Kiffer. Thus, Whitton et al. (2002) re-described it under a new specific name, *Balaniopsis kirkii* Whitton et al. Another new species, *Balaniopsis dendroidea* Whitton et al., with globose conidia and branched conidiophores, was described by Whitton et al. (2002). *Balaniopsis triangularis* is different from the other three species in its much smaller, triangular conidia (6.0–7.4 × 6.4–8.6 μm), obovoid or obconic conidiogenous cells, and reduced separating cell.

Balaniopsis triangularis is in some ways similar to *Stellomyces kendrickii* Kesh. Prasad & Bhat (Keshava Prasad & Bhat 2002). However, although the conidia of *S. kendrickii* are often triangular, they have an attenuated base and arise from very narrow extensions of the conidiogenous cell. In addition, in *Stellomyces*, one conidiogenous cell may give rise to several clusters of conidia (which may be terminal or intercalary) and that conidiogenous cell may even be branched, with more than one cluster at the end of each branch. In *B. triangularis*, the conidiogenous cell is not branched; each conidiogenous cell gives rise to only one cluster of conidia which is always terminal; and the conidia do not arise on fine outgrowths like those seen in *Stellomyces.*

The holotype was collected from a wooden structure in crawl space of a building and could not be isolated in pure culture. It would appear that the material had been in situ for so long that the mycelium and spores had died.

Although rare, this fungus occurs with significant frequency on building materials, where its presence needs to be acknowledged and recorded. It is our opinion that it is now necessary and appropriate to make available a binomial for this organism.

Key to species of *Balaniopsis*

1. Conidiophores typically dichotomously branched; conidia brown to pale brown, more or less spherical, 8.5–13µm diameter. . . . . *B. dendroidea*

1. Conidiophores unbranched 2

2. Conidia broadly obovoid, dark brown, 12.8–14.5 × 9.5–11µm . . . . *B. kirkii*

2. Conidia more or less triangular 3

3. Conidiophores with a distinctive light–dark–light pigmentation pattern; conidia brown to pale brown, 9–12 × 7–10µm. . . . . *B. africana*

3. Conidiophores concolorous; conidia yellow, 6.0–7.4 × 6.4–8.6µm . . . . *B. triangularis*

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Radiigera tropica (*Geastraceae, Geastrales*), a new species from a tropical rain forest of Thailand

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Abstract — A new species, *Radiigera tropica,* is described and illustrated from a tropical rain forest of Thailand dominated by *Dipterocarpus* spp. The species is morphologically characterized by a felty to floccose peridial surface, a four-layered peridium and small, globose basidiospores (3-4.6 μm diam) with low, dense verrucae. Moreover, some specimens have minute, granular peridioles. Additionally, it shares characteristics of both previously recognized subgenera, *Taylorae* and *Radiigera.* Following a taxonomic description, reconsideration of these subgenera and characterization of the species among previously described *Radiigera* species are discussed.

Key words — *Geastrum,* sequestrate fungi, gasteromycetes, taxonomy, *Phallomycetidae*

Introduction

Members of the genus *Radiigera* Zeller (*Geastraceae, Geastrales*) produce hypogeous to subepigeous basidiomata that strongly resemble immature basidiomata of *Geastrum* spp. but are macroscopically distinguishable from the latter in that the basidiomata either do not open in a stellate manner or remain closed at maturity. So far, four species of *Radiigera* have been recognized from North America and Europe (Zeller 1944, Guzmán 1971, Kers 1976, Domínguez de Toledo & Castellano 1996). The crucial morphological difference is that even when immature, *Radiigera* lacks both a well-developed endoperidium and an apical pore, which are universally present in *Geastrum* spp. (Domínguez de Toledo & Castellano 1996). Molecular phylogenetic analysis of three *Radiigera* species with a concatenated five-locus dataset of nuclear and mitochondrial DNA strongly supports nesting of *Radiigera* spp. within the *Geastrum* spp. clade and implies that *Radiigera*, as currently recognized, is polyphyletic (Hosaka 2005, Hosaka et al. 2006).

In this paper, we describe and illustrate a new hypogeous fungus collected from a tropical rain forest dominated by *Dipterocarpus* spp. in Songkhla Province, Southern Thailand. We provisionally assign the species to *Radiigera*, a genus that hitherto has not been reported from Asia, based on macro- and micromorphological characters.

Methods

The specimens examined are deposited in the mycological herbaria of National Museum of Nature and Science, Tokyo, Japan (TNS), Prince of Songkla University, Hat Yai, Thailand (PSU) and Natural History Museum and Institute, Chiba, Japan (CBM).

Fresh basidiomata collected in the field were observed macroscopically and then air-dried for later examination. Free-hand sections of the specimens were mounted in water, 5% KOH or Lactophenol-Cotton blue for standard light microscopy. Each micromorphological structure was measured in Lactophenol-Cotton blue on glass slides. Measurement of spores was from mature specimens. Spore dimensions were based on the measurement of 50 randomly selected spores. Color names are in general terms of the authors.

The surface features of spores were observed by scanning electron microscopy (SEM). For SEM, gleba was dusted onto a specimen holder attached with double-sided adhesive tape and then coated with platinum-palladium with an E-1030 Ion Sputter Coater (Hitachi, Tokyo, Japan). The treated gleba was examined with an S-4200 SEM (Hitachi, Tokyo, Japan) operating at 20.0 kv.

Taxonomy

Radiigera tropica Orihara & T. Kasuya, **sp. nov.** FIGURES 1–10

MYCOBANK MB 511725

Basidiomata globosa vel depresso-globosa, ca. 2.2 cm in diam., superficie coacta vel floccosa, spadicea vel brunneola. Peridium 4-stratosum; stratum myceliale ochraceum, ex hyphis crassitunicatis compositum, quae exterioribus laxe intertextis 2.5–6 µm latis interioribus dense intertextis 1–3 µm latis compositum, cum contextu intimo amorpho 30–65(140) µm crasso; stratum fibrosum 20–350 µm crassum, ex hyphis crassitunicatis, hyalinis, intertextis, 2.5–6.3 µm latis compositum; stratum pseudoparenchymatum 280–500 µm crassum, ochraceum vel brunneum; endoperidium nullum vel depauperatum. Gleba atro-brunnea, pulverulenta, saepe cum peridiolis subglobosis usque ad 150 µm diam. Capillitium 2.5–7 µm latum, crassitunicatum, fuscum, non sinuosum, non septatum, cum *granulis reliquis haerens. Basidiosporae globosae, verrucosae, 3–4.6 µm diam., verrucis minutis, densis.*

Holotypus: *THAILAND, Songkhla Province, Ton Nga Chang Waterfall, fere hypogaea in silvis tropicali, 21 Feb.2005, leg. T. Kasuya (TNS-F-17629).*

Etymology: Latin, tropica refers to the characteristic distribution of the species.

Basidiomata hypogeous, globose to depressed globose, ca. 2.2 cm in diam., surface felty to floccose with debris, pale tawny to pale brown, thick hyphal mat not observed in soil, basal rhizomorphs of pale brown, thick-walled (0.4–0.7 µm thick), filamentous hyphae parallel to surface with scattered, clamped, non-ampullate septa, 1–2 µm broad. Peridium four layered; exoperidium (= mycelial layer) 200–450 µm thick, tawny to pale brown, further divided into three layers: the outer hyphal layer 80–220 µm thick, acyanophilous, of thick-walled (0.8–2.0 µm thick), yellowish brown, aseptate, loosely interwoven or partly perpendicularly arranged, filamentous hyphae, 2.5–6 µm broad, grading to inner; the inner hyphal layer 80–200 µm thick, acyanophilous, of thick-walled (0.4–1.4 µm thick), brown, aseptate, densely interwoven, narrow, filamentous hyphae, 1–3 µm broad, grading to inner amorphous stratum; the innermost exoperidial layer (= amorphous stratum) 30–65(140) µm thick, cyanophilous, where the mycelia collapse in mature specimens; fibrous layer 20–350 µm thick, acyanophilous, easily separable from the exoperidium, of thick-walled (1–3 µm thick), white, refractive, aseptate, loosely interwoven, filamentous hyphae, 2.5–6.3 µm broad; inner layer (= mesoperidium) 280–500 µm thick, of persistent, ochraceous to brown, thick-walled (0.7–2.6 µm thick) pseudoparenchymatous cells up to 25 µm in diam.; endoperidium absent or if present, poorly developed, comprised of pale grayish brown to reddish brown, thick-walled (0.8–4 µm thick), aseptate, densely interwoven hyphae, 3–10 µm broad. Columella indistinct, more or less columnar, white, collapse at maturity, of thick-walled (0.5–0.8 µm thick), branched, interwoven hyphae 1–5.5 µm broad, clamp-connections absent. Gleba white at immaturity, then becoming blackish brown, powdery at maturity, in some immature specimens comprised of radially arranged cylindrical elements, ca. 1 × 0.1–0.2 mm, along with a mass of granular peridioles, in other immature specimens never comprised of such cylindrical elements or peridioles; cylindrical elements consisting of bundles of tubular peridioles comprised of pale brown, palisade basidiole-like cells, and tubular elements comprised of helicoid filamentous hyphae, 0.8–2 µm broad which partly loosen; The granular peridioles subglobose to depressed-globose, 15–30 × 20–52 µm at immaturity, 40–150 × 25–100 µm at maturity exposing a blackish mass of basidiospores, comprised of hyaline to pale brown, palisade cells deliquescing at maturity. Capillitial threads 2.5–7 µm broad, more or less bundled, thick-walled (0.8–2.8 µm thick), pigmented with pale brown to dark brown, non-branched, straight, non-septate, surface often covered with adherent debris, appearing almost warty. Basidia not observed in peridioles; in specimens not containing peridioles, sacciform to lecythiform, hyaline, 4–8-spored, ca. 12–25 × 7–14 μm, collapsing at maturity; generative hypahe hyaline, thin-walled, filamentous, more or less sinuate, 0.8–5 μm broad, with scattered clamp connections, collapsing at maturity. Basidiospores globose, minutely and densely warty, dark brown to blackish brown, 3–4.6 μm in diam. (4 μm in mean diam.) including ornaments, basal apiculus not prominent, almost flat, not forming ridges with the surrounding verrucae.

Habitat — Hypogeous, gregarious under *Dipterocarpus* spp.

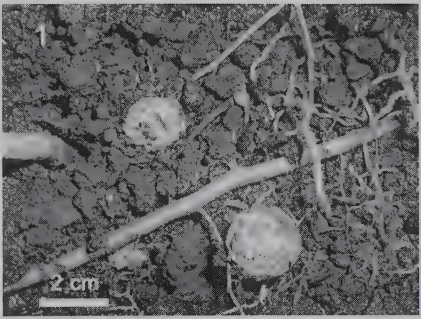
Distribution — Known only from Thailand (Songkhla Province).

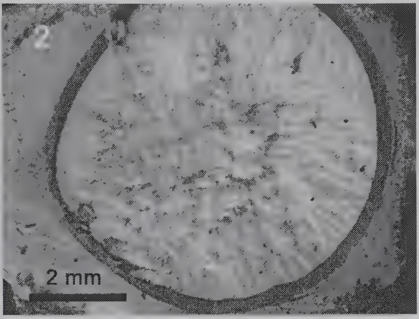
Specimens examined — **THAILAND. Songkhla Province**: Ton Nga Chang Waterfall, February 21, 2005, T. Kasuya, *Orihara 605*, TNS-F-17629 (holotype), PSU-FB-21205 (isotype), CBM-FB-37171 (isotype); December 6, 2005, T. Kasuya, S. Phogpaichit and Y. Dissara, *Orihara 662*, TNS-F-17661.

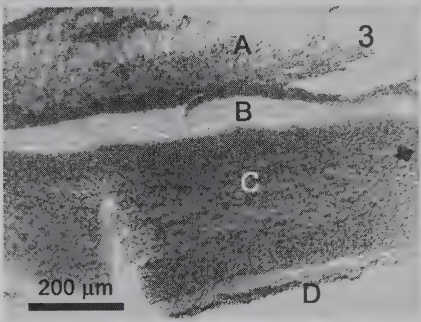
Discussion

Ecologically, *Radiigera tropica* occurs in tropical rain forest dominated by *Dipterocarpus* spp. Although *Dipterocarpus* spp. are known as major ectomycorrhizal host trees in the habitat, ectomycorrhizal association of *R. tropica* has not yet been confirmed. *Radiigera tropica* is morphologically characterized by the felty to floccose peridial surface with debris, the four-layered peridium and the small basidiospores with low, dense verrucae. Another notable feature is the presence of two glebal types: some specimens have the radially arranged cylindrical elements and tubular or granular peridioles within the gleba (Figs. 5–7), but others, as well as the remaining *Radiigera* species, never contain these tissues (Fig. 2). The immature peridioles of the former glebal type are comprised of palisade cells although we did not observe any basidiospores within them in early developmental stages. It is known that *Schenella* T. Macbr. (= *Pyrenogaster* Malençon & Riousset), a genus recently transferred from *Myxomycetes* to *Basidiomycetes* (Estrada-Torres et al. 2005) and closely related to *Radiigera,* forms peridioles. However, the generic characters of *Schenella* — such as smooth capillitium, filiform basidia and absence of the fibrous layer in the peridium — were not observed in *R. tropica.* Additionally, the mass of minute, granular, subglobose peridioles of *R. tropica*

Figs. 1–10. *Radiigera tropica* (from holotype). 1. Basidiomata. 2. Cross-section of a dried immature basidioma without peridioles. 3. Peridium: A. Exoperidium. B. Fibrous layer. C. Inner layer (mesoperidium). D. Endoperidium. 4. SEM photomicrograph of a basidiospore with an indistinct basal apiculus. 5. Glebal cylindrical elements along with minute, immature granular peridioles. 6. Immature, granular peridioles. 7. Cylindrical elements in the immature gleba. 8. Basidiospores. 9. Basidia. 10. Capillitium. Bars: Figs. 8–10 = 10 μm.



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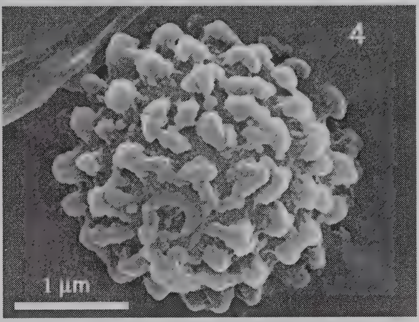

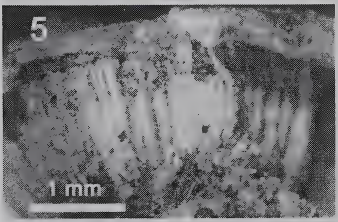

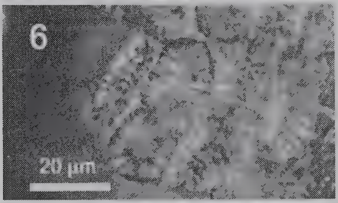

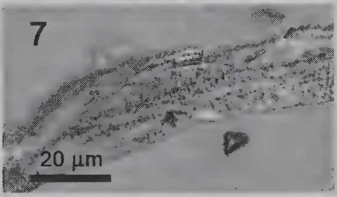

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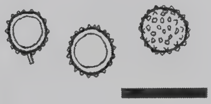

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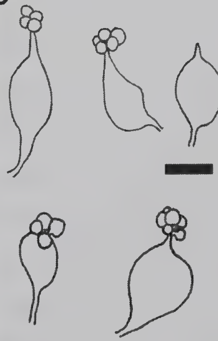

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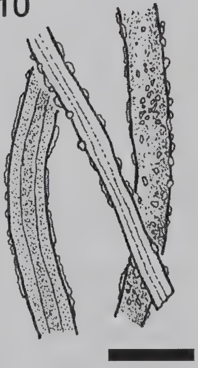

has little morphological affinity with the radially arranged, conical to pyramidal peridioles of *Pyrenogaster* species. Therefore, we consider that there is not a close relationship between *R. tropica* and *Schenella* spp. and that the placement of *R. tropica* within the genus *Radiigera* is justifiable. Further molecular studies may reveal a different phylogenetic relationship of the species.

Of all known taxa of *Radiigera, R. taylorii* (Lloyd) Zeller most closely resembles *R. tropica* in overall peridial structure and small (3–4 μm diam) basidiospore size but is distinguished by a smooth peridial surface, perpendicularly arranged hyphae of an outermost exoperidial layer and less densely arranged verrucae of basidiospores. *Radiigera fuscogleba* Zeller differs from *R. tropica* in producing thin-walled exoperidial hyphae with clamp connections and larger basidiospores (4.5–7(8) μm diam, Domínguez & Castellano 1996). The felty to cottony surface of *R. bushnellii* L.S. Domínguez & Castellano reminds us of *R. tropica*, but *R. bushnellii* differs in having an undifferentiated exoperidial structure, a poorly developed (sometimes absent) capillitium and a more or less protruding basal basidiospore apiculus that forms ridges with the surrounding verrucae. *Radiigera flexuosa* L.S. Domínguez & Castellano is unique in having irregularly dehiscent basidiomata, a three-layered peridium and thin-walled, contorted, sinuous capillitial threads, all of which are not observed in *R. tropica.*

Domínguez de Toledo & Castellano (1996) recognized subgenus *Taylorae* for *R. taylorii,* which was defined by small (3–4 μm diam.), globose basidiospores, a peridial mycelial layer of thick-walled hyphae perpendicularly arranged towards the outside, and a peridial surface that is smooth and without adherent debris. The other three species (i.e., *R. fuscogleba, R. bushnellii* and *R. flexuosa*) were placed in subgenus *Radiigera* Zeller. *Radiigera tropica*, however, shares subgeneric characters of both subgenera *Taylorae* and *Radiigera*: relatively small basidiospores and thick-walled exoperidial hyphae are characteristic of subgenus *Taylorae,* whereas the felty to floccose peridial surface with adherent debris and the loosely interwoven or less perpendicularly arranged outermost exoperidial hyphae are characteristic of subgenus *Radiigera.* Moreover, molecular phylogenetic analyses by Hosaka et al. (2006) indicate a well-supported phylogenetic affinity between *R. taylorii* and *R. bushnellii* (i.e. >0.95 Bayesian posterior probability; >70% maximum parsimony bootstrap value), suggesting that the taxonomic boundary between subgenera *Taylorae* and *Radiigera* is artificial. The phylogenetic study further suggests that the genus *Radiigera* as currently delimited is artificial and that all species except the type (*R. fuscogleba)* should probably be assigned to *Geastrum* (Hosaka et al. 2006, Hosaka pers. comm. 2008). Therefore, our assignment of *R. tropica* to *Radiigera* is provisional, subject to taxonomic re-evaluation pending future molecular analyses. In summary, reconsideration of both infra- and intrageneric classification in *Radiigera* with more detailed molecular methods would be useful in the future.

Radiigera tropica is the first *Radiigera* species recorded from Asia and tropical regions. Its presence suggests that *Radiigera* has wide distribution from tropical to boreal areas. Although *Radiigera* is a small genus, more intensive studies in Asia and its adjacent areas may reveal additional species diversity.

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A new genus, *Cruentomycena*, with *Mycena viscidocruenta* as type species

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Abstract — *Mycena viscidocruenta* is presently known only from the Antipodes. Collections from far eastern Russia were shown to be closely related both by morphology and by sequence homology. Phylogenetic analyses based on ribosomal LSU and ITS sequences show that the *M. viscidocruenta* clade is sister to *Panellus stypticus* and *Panellus* (*Dictyopanus*) *pusillus*, two laterally stipitate taxa, in the panelloid clade. *Resinomycena rhododendri*, the type species of *Resinomycena* is basal to this group. A new genus, *Cruentomycena*, is proposed to accommodate *C. viscidocruenta* (typus generis) and a new species, *C. kedrovayae*.

Key words — biodiversity, biogeography

Introduction

Mycena viscidocruenta is a small (cap 7–11 mm), bright red agaric with a very slimy stem and cap. Fruiting on leaves and small woody debris, it has been reported from the southeastern Australian mainland and Tasmania (Grgurinovic 2002; Fungimap, Australia: http://fungimap.rbg.vic.gov.au), and from the North and South Islands of New Zealand (McKenzie et al. 2000, on *Nothofagus* debris; Segedin & Pennycook 2001; E. Horak, pers. com.). An LSU rDNA sequence of Tasmanian material was used by Moncalvo et al. (2002), who showed that collection to belong to the panelloid clade (denoted as /panelloid). That paper further noted that a relationship among *Resinomycena rhododendri* (typus generis), *Mycena viscidocruenta*, *Panellus* (pleurotoid, lamellate) and *Dictyopanus* (pleurotoid, poroid) had not previously been reported (Singer 1986), but did not discuss morphological circumscription of *M. viscidocruenta* or the proposed merger of *Dictyopanus* and *Panellus* (Burdsall & Miller 1975).

Two collections of a similar agaric from the Primorsky Territory in far eastern Russia on *Alnus* catkins were thought to greatly extend the geographic range of the species (Petersen & Hughes 2007); the known distribution of *M. viscidocruenta* does not include temperate east Asia or any geographical region between Russia and southern Australia/New Zealand.

The identity of the source of an LSU DNA sequence (Moncalvo et al. 2002) was insecure, and the temperate Russian collections, while molecularly close to Tasmanian material, seemed undescribed. This paper takes up this small problem with the following intent: 1) redescription of *Mycena viscidocruenta* from additional Australian specimens including the type; 2) description of the Russian taxon; 3) discussion of the molecular placement of these collections; and 4) proposal of a new genus name to accommodate these specimens.

Methods and materials

Morphological analyses

In order to associate morphological features with DNA sequences, specimens from Kew (K) and Adelaide (AD) were borrowed and examined (see below). All observations were with Phase Contrast optics (PhC), with magnification up to 1200× on an Olympus BX60 research microscope. Colors within quotation marks are from Ridgway (1912); those cited alphanumerically are from Kornerup & Wanscher (1967).

Molecular protocols

For DNA extractions from herbarium specimens, a small piece of gill tissue was removed and ground to a fine powder with sterile grinding sand. The mixture was added to a CTAB extraction buffer (Carlson et al. 1991) and extracted as described in Mata et al. (2007) or extracted using a Qiagen DNA easy Plant Mini Kit following manufacturer's instructions. PCR amplification of the ribosomal ITS1-5.8S-ITS2 region was carried out with primers ITS1F and ITS4. PCR of the ribosomal Large Subunit 3' end was carried out with primers LR7 (Moncalvo et al. 2000) and ITS3. DNA sequencing followed manufacturer's directions for Big Dye Terminator mix (ABI) with forward primer ITS5 and reverse primer ITS4 for the ribosomal ITS region and primers LR5, LR21 and LR0R for the LSU region. Primers ITS3, ITS4 and ITS5 are described in White et al. (1990); Primer ITS1F is described in Gardes & Bruns (1993); Primers LR5, LR21 and LR0R are given in Moncalvo et al. (2000). Sequences were aligned and compared using the GCG suite of programs (GCG 2000). Sequences obtained for this study are given in Table 1.

Molecular Data Analyses

Initial sequence alignments were carried out using the "pileup" program in GCG which performs UPGMA, followed by manual adjustments to the alignment. For both ITS and LSU regions, *Mycena* (*Prunulus*) *pura* was selected as an outgroup based on Moncalvo et al. (2002), on blast homology in Gen Bank and on preliminary parsimony analyses which included other *Mycena* and *Favolaschia* species. There were extensive but informative gaps in ITS sequences of *Panellus stypticus* collections from Australia

Table 1. Collections sequenced for phylogenetic analyses and GenBank Numbers

GENBANK NUMBERS	HERBARIUM DESIGNATION	COLLECTION #	NAME	COLLECTION LOCATION
MYCENA				
EU517504	TENN 60106	12167	*Mycena pura*	Russia, Samara Region, Zhigulevsky Nature Reserve
EU517505	TENN 60139	12202	*Mycena pura*	Russia, Samara Region, Zhigulevsky Nature Reserve
EU517506	TENN 60747	11863	*Mycena pura*	Russia, Primorsky Territory, Khasansky Dist.
DQ490643* DQ475688* DQ457689*	CUW PBM2665	PBM2665	*Mycena afn pura*	USA, Massachusetts (LSU has two clones)
RESINOMYCENA				
AF042638*	DAOM169949*		*Resinomycena acadiensis*	Canada, New Brunswick, Kouchibouguac National Park,
AF261415*	not given	JEJ.VA.599	*Resinomycena rhododendri*	USA, Virginia
EU517507	TENN61536	13275	*Resinomycena rhododendri*	USA, TN, GSMNP
EU517508 EU517509 EU532599 (LSU)	TENN50793	3674 clones 1,2	*Resinomycena rhododendri*	USA, TN, GSMNP
EU517510	TENN48598	1852 clone 3	*Resinomycena rhododendri*	USA, NC, GSMNP
CRUENTOMYCENA				
AF261414*	DUKE3411		*Cruentomycena viscidocruenta*	Australia, Tasmania
EU517513 EU517514	TENN60716	11831 clones 1,2	*Cruentomycena kedrovaya*	Russia, Primorsky Territory, Kedrovaya Pad Nature Reserve
EU517512	TENN60729	11844	*Cruentomycena kedrovaya*	Russia, Primorsky Territory, Kedrovaya Pad Nature Reserve
EU517511	LE212084 Culture LE(BIN)-2000	NPSURTSEVA 2000H	*Cruentomycena kedrovaya*	Russia, Primorsky Territory, Kedrovaya Pad Nature Reserve
EU517515 EU517516 EU517517 EU517518	K(M)117458	G&R0368 clones 1,3,4,5	*Cruentomycena viscidocruenta*	Australia, Tasmania, Cloned sequences

Table 1, concluded.

PANELLUS				
AF289061	TENN 54324	8265	*Panellus (Dictyopanus) pusillus*	USA, Florida
AF261426*	TENN53778	7699	*Panellus (Dictyopanus) sp.*	Australia, Victoria
AF261425*		RV.PR98/36	*Panellus (Dictyopanus) sp.*	Puerto Rico
AY014291	TENN54317	8265		USA, Florida
L43376*	FP- HBB9759	PNXRGEBNA	*Panellus pusillus*	USA, Florida
L43375*	FP-102581	PNXRGEBN	*Panellus pusillus*	USA, Louisiana
AF518634*	CUW DSH93-213	DSH 93-213	*Panellus stypticus*	USA, Massachusetts (Callahan State Park)
AF261427*	not given	CMC5	*Panellus stypticus*	not given
AY398745*	TUB-GLM51801	GLM51801	*Panellus stypticus*	Germany
AY014292	TENN50398	4319	*Panellus stypticus*	Switzerland
AF289062	TENN 50039	3541	*Panellus stypticus*	Australia, N.S.W.
AF289063	TENN 50140	3586	*Panellus stypticus*	Australia, Tasmania
EU517519	TENN 61073	13069	*Panellus stypticus*	New Zealand, South Island, Nelson Dist
AF289064	TENN 48833	2675	*Panellus stypticus*	New Zealand, Fiordland
EU517520	TENN 61087	13083	*Panellus stypticus*	New Zealand, South Island, Buller Dist
EU517521 EU517522	TENN 61074	13070 haplotypes 1,2	*Panellus stypticus*	New Zealand, South Island, Nelson Dist
EU517523	TENN 60969	12854	*Panellus stypticus*	New Zealand, South Island, Fiordland
AF289071	TENN 52316	6157	*Panellus stypticus*	USA, TN, Polk Co.
AF289070	TENN 56339	9525	*Panellus stypticus*	Canada, near Montreal
EU517528	TENN 59998	11940	*Panellus stypticus*	USA, TN, GSMNP, Schoolhouse gap
EU517533 EU517534	TENN 60315	12067 haplotype 1,2	*Panellus stypticus*	USA, TN, GSMNP, Newfound Gap
EU517531 EU517532	TENN 60358	12310 haplotypes 1,2	*Panellus stypticus*	USA, TN, GSMNP, Miggs Creek Tr
EU517529 EU517530	TENN 60486	12411 haplotypes 1,2	*Panellus stypticus*	USA, NC, GSMNP, Kephart Prong
AB084488*	none given	99-334	*Panellus stypticus*	Japan
AF289066	TENN 48835	3342	*Panellus stypticus*	Russia, Primorsky Territory
AF289068	TENN 50607	4271	*Panellus stypticus*	Sweden
AF289069	TENN 50398	4319	*Panellus stypticus*	Switzerland
AF289065	TENN 55360	8234	*Panellus stypticus*	USA, Alaska, vic. Juneau
AF289067	TENN 58325	9029a	*Panellus stypticus*	USA, California
EU517524	TENN 59678	11137	*Panellus stypticus*	Austria
EU517525	TENN 59623	11660	*Panellus stypticus*	Russia, Novgorod Region
EU517526 EU517527	TENN 60735	11851 haplotypes 1,2	*Panellus stypticus*	Russia, Primorsky Territory, Kedrovaya Pad Nature Reserve

FP = USDA Forest Service, Forest Products Laboratory, Wisconsin, GSMNP = Great Smoky Mountains National Park

* Sequences not generated by authors

and New Zealand (Jin et al. 2001b). For this ITS data set, gaps were treated as missing in maximum parsimony analysis. An additional 172 bases representing four regions of the ITS area were deleted in all analyses because alignment of outgroups with ingroups was uncertain. Gaps were minimal but informative in the LSU data set and maximum parsimony was performed with gaps treated as a fifth base.

Maximum parsimony was performed using PAUP* (Swofford 2001). Characters were unordered and weighted equally. Trees were limited to 100; multistate taxa were interpreted as uncertainty; starting trees were obtained via stepwise addition; addition sequence = furthest; the number of trees held at each step during stepwise addition = 1; branch-swapping algorithm was tree-bisection-reconnection (TBR); steepest descent option was not in effect; maxtrees setting = 100. One-thousand bootstrap replicates were performed. Modeltest was used to determine the appropriate model of evolution for Bayesian analysis (Posada & Crandall 1998). The model selected by Model Test was a general time reversible model with rate variation (gamma) and both variable and invariant sites (GTR+G+I). Bayesian analysis was performed using Mr Bayes (Huelsenbeck & Ronquist 2000) with the following settings; nst = 6, basefreq = estimate. The MCMC search was run with 4 chains for 500,000 generations with sampling every 100 generations. The first 1,000 trees were discarded and "burnin" based on preliminary analyses showing that likelihood values had reached stability with the first 1000 trees. Posterior probabilities were estimated by sampling trees generated after likelihood values diverged.

Results

Taxonomic description

Cruentomycena R.H. Petersen, Kovalenko & O. Morozova, **nom. et stat. nov.**
MycoBank mb 511635

Basionym: *Mycena* sect. *Viscidocruentae* Maas Geest. & Hauskn. 1998. Österr. Zeitschr. Pilzk. 7: 127.

Type species: *Cruentomycena viscidocruenta* (Cleland) R.H. Petersen & Kovalenko.

Etymology: cruentus = splashed with blood; *Mycena* = resembling *Mycena*.

Basidiomata mycenoidea vel marasmielloidea. Pileus diminutivus, planus ad depressus, viscidus, sanguineus; trama pseudoparenchyma, pseudoamyloidea. Lamellae arcuatae ad decurrentae, crassae, cinnabar-sanguineae, marginatae. Stipes tenuis, levis, aequalibus. Hab: in ramunculi et folia. Hyphae pileipellis angustae, tenuitunicatae, fibulatae. Cheilocystidia praecentia. Pleurocystidia nulla. Sporae elongatae, amyloideae.

Discussion: In proposing a new genus name, elevation of the section name would have produced a tautonym, *Viscidocruenta viscidocruenta*, illegitimate under the ICBN [(Vienna) Art. 23.4]. A new genus name is therefore necessary.

Cruentomycena viscidocruenta (Cleland) R.H. Petersen & Kovalenko, **comb. nov.**
MycoBank mb 511636

Basionym: *Mycena viscido-cruenta* Cleland. 1924. Trans. Proc. Roy. Soc. S. Australia 48: 239. [nom. nov. for *Mycena coccinea* Cleland & Cheel. 1919. Trans. Proc. Roy.

Soc. S. Australia 43: 284, nom. illeg., non *M. coccinea* (Sowerby) Quél. 1880 [1879]. Bull. Soc. Amis Sci. Nat. Rouen II 15: 155].

LECTOTYPE: (design. Grgurinovic 1997): AUSTRALIA, New South Wales, Mosman, S 33° 14', E 150° 50' (precn. 3), 24.V.1914, coll. J.B. Cleland (as *Mycena coccinea*), det. C.A. Grgurinovic (as *M. viscidocruenta*), (JBC) s.n. (AD-C12182).

EXEMPLAR — AUSTRALIA, Victoria, Sherbrooke Forest, Hardy Creek, S 37° 53'43", E 145° 21' 44" (precn 3), 2.IV.1981, coll. & det. CA Grgurinovic, CAG 9481 (AD-C12334).

COLOR ILLUSTRATIONS — Cleland & Cheel (1919), Grgurinovic (1997). http://www.landcareresearch.co.nz.

MACROCHARACTERS — BASIDIOMATA (Fig. 1a) small, mycenoid; PILEUS 4–11(–14) mm broad, plane to shallowly convex, centrally depressed or almost umbilicate, viscid to glutinous when fresh, laccate to matt when dried, rich reddish crimson, blood red, minutely rugulose, outward gently crenate, deeply striate, color red-black upon drying; margin subcrenate when fresh, sometimes appearing striate and often inrolled when dried; LAMELLAE subdistant, adnate with decurrent tooth to arcuate, terminating quite abruptly on stipe, thick, slightly paler than cap (rose color of Cleland) and becoming dark cinnabar to pallid gray-mauve on drying, very minutely denticulate, lamellar edges very slightly darker than lamellar face when fresh, distinctly marginate to blood red or deep purple upon drying; STIPE 6–25 mm long, 0.4–1 mm broad, terete, equal, glutinous to viscid, blood red, hollow, perhaps producing minimal blood-red juice upon bruising; base sometimes swollen into a hemisphere or a rounded carbuncle concolorous with stipe, occasionally with superficial cinnabar tomentum. Red pigment leaching copiously in formalin (Cleland) and KOH.

HABITAT — On fallen twigs and associated leaf fragments; "deep shady places" (Cleland).

MICROCHARACTERS — PILEIPELLIS with superficial viscid layer (with adherent spores) covering radially oriented, thin-walled (easily overlooked), unornamented hyphae 4–9 µm diam., hardly inflated, not encrusted, frequently septate and occasionally demonstrably clamped; terminal cells undifferentiated, simply rounded apically. Pileus trama of significantly inflated hyphae up to 28 µm diam., thin-walled, constricted at septa, clamped, almost pseudoparenchymatous, perhaps weakly pseudoamyloid; BASIDIA (Fig. 1b) 20–25 × 6–8 µm, clavate, clamped, thin-walled, 4-spored; sterigmata persistent after spore discharge, awl-shaped, stiff; BASIDIOSPORES (Fig. 1c) amyloid, (6.5–)8–10 × (2.5–)3–4.5 µm, thin-walled, elongate pip-shaped, tapering asymmetrically toward hilar appendage, aguttulate, hyaline. Lamellar trama irregular, of somewhat inflated cells, weakly pseudoamyloid (but difficult to distinguish from merely pink-pigmented; CHEILOCYSTIDIA (Fig. 1d,e) scattered along lamellar edge, dimorphic: 1) (Fig. 1d) 17–42 × 11–24 µm,

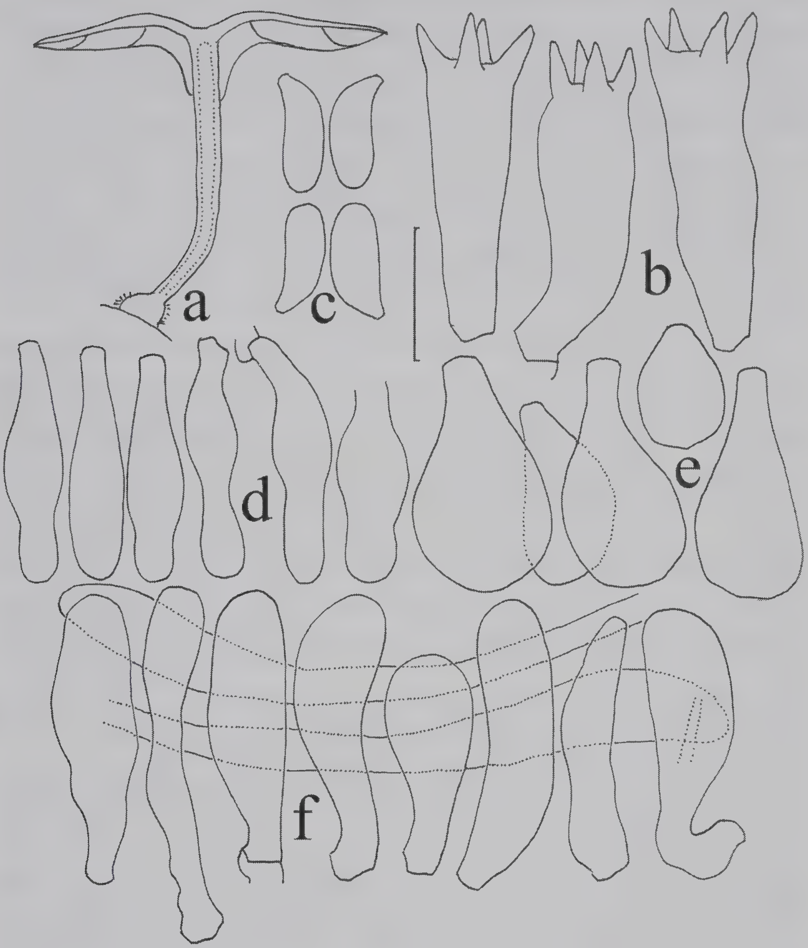

Fig. 1. *Cruentomycena viscidocruenta*. AD-C12334.
a. Basidiome, ×6. b. Basidiospores. c. Basidia. d, e. Cheilocystidia. f. Caulocystidia.
Standard bar = 10 µm for basidiospores and basidia, otherwise = 20 µm.

sphaeropedunculate to almost sessile, very thin-walled; and 2) (Fig. 1e) 27–41 × 7–14 µm (at widest point), ten pin-shaped or sublecythiform with narrowed neck and slightly expanded capitulum (6–7 µm broad). Stipe surface covered with thin viscid layer; hyphae strictly parallel, thin-walled, 3.5–7 µm diam., infrequently septate, ?clamped; occasionally producing out-turned hyphal tips; CAULOCYSTIDIA (Fig. 1f) somewhat inflated, 28–>75 × 8–14 µm, thin-walled, of undetermined origin; contents homogeneous, with very pale pinkish tint.

Commentary — At least three of the collections listed below were in the hands of Cleland at the time he and Cheel proposed *M. coccinea*, and therefore, together with additional specimens at AD not examined, constitute a group of syntypes, from which Grgurinovic (1997: 261) chose a lectotype (see above). Fungus material remaining in the lectotype, however, is meager, so a more recent collection (AD-C12334) has been cited as "exemplar." The designation "epitype" is not used here, in hopes that a future, more appropriate collection can be employed to extract DNA for comparison.

We have seen no specimen comprising more than three basidiomata, implying that when found in nature, only a few basidiomata are produced by a single, localized mycelium.

Macromorphologically, the specimens of *C. viscidocruenta* (including those labeled as *M. coccinea*) are nearly inseparable from the Russian material: colors of pileus, lamellae, lamellar edge, and stipe all match. Size ranges of basidiomata from the two regions were also similar, as were basidiospores, basidia and caulocystidia. although habitat clearly differs. Cleland & Cheel (1919) noted that color leached from tissues in formalin, and the phenomenon is also strong in KOH. Conversely, Russian material exhibits only one type of cheilocystidia while Australian specimens clearly produce two types mixed over the lamellar edge, and cheilocystidia of similar shape are smaller in the Russian material. Spores are comparable, although rough measurements might indicate that in Russian specimens they are slightly wider. Russian material was not obviously viscid when collected even though it had been raining for several days, but Maas Geesteranus & Hausknecht (1998) briefly discussed discrepant reports on this character, including that by Grgurinovic & Holland (1982).

Grgurinovic (1997) placed *M. viscidocruenta* in sect. *Hygrocyboideae* (Fr.) Singer, with further placement in subsect. *Gummosae* (J.E. Lange) Oort. Maas Geesteranus & Hausknecht (1998) recognized the species as unique, and proposed sect. *Viscidocruentae* to accommodate it. Grgurinovic (2002) examined numerous specimens, citing its distribution as south-eastern Australia, Queensland and New Zealand. Neither Grgurinovic (1997, 2002) nor Maas Geesteranus & Hausknecht (1998) anticipated that DNA sequences would show it to be even less related to the bulk of *Mycena*, and a candidate for genus rank.

Cleland made reference to a specimen in formalin (note with AD-C12187) but this specimen has been lost. The same specimen was said to resemble "Miss Clarke Fig., A3 [believed to be on p. 4 of Cleland folder]" a reference to a watercolor rendering thought to still exist in a folder of Cleland illustrations at AD. This watercolor may have been published as Cleland & Cheel (1919: Pl. 29, Fig. 4).

Cleland furnished spore measurements, which closely match those reported above. (Cleland: 7–8.2 × 2.5–3.4 μm; 8.5 × 3.5 μm; 8 × 3.8 μm).

Specimens examined — **AUSTRALIA**, **New South Wales**, **Mosman**, S 33° 14', E 150° 50', 21.VI.1914, coll. JB Cleland (as *M. coccinea*), s.n. det. C.A. Grgurinovic (as *M. viscidocruenta*). AD-C12187 (formerly ADW 12195, "type", later labeled as "syntype"); **Mosman**, S 33° 14', E 150° 50' (precn. 3), 24.V.1914, coll. J.B. Cleland (as *Mycena coccinea*), det. C.A. Grgurinovic (as *M. viscidocruenta*), (JBC) s.n. (AD-C12182; lectotype); **South Australia**, **Southern Lofty, Waterfall Gully**, S 34° 57' 43", E 138° 40' 17" (precn: 3), 19.VI.1921, coll. J.B. Cleland (as *M. coccinea*), det. C.A. Grgurinovic (as *M. viscidocruenta*), ADW 12201 (AD-C12318); **Tasmania**, **Mount Wellington**, Myrtle Gully, 25.III.2003, coll. G. Gates & D.A. Ratkowsky G&R 0368, K(M) 117458); **Victoria**, **Sherbrooke Forest**, Hardy Creek, S 37° 53'43", E 145° 21' 44" (precn 3), 2.IV.1981, coll. & det. CA Grgurinovic, CAG 9481 (AD-C12334); **Victoria**, **Sherbrooke**, Hardy Creek, S 37° 53' 43", E 145° 21' 44" (precn 3), 30.III.1981, coll. & det. C.A. Grgurinovic, CAG 11381 (AD-C12256); **Victoria**, **Glen Nayook**, S 37° 55' 22", E 145° 56' 43" (precn 3), 15.IV.1981, coll. & det. C.A. Grgurinovic, CAG 20481 (AD-C12277).

Cruentomycena kedrovayae R.H. Petersen, Kovalenko & O. Morozova, sp. nov.

MycoBank mb 511637 Fig. 2

Ut C. viscidocruenta, *vel stipite et pilei vix glutinosa, habitat in Alnus amenta et ramunculi, cheilocystidia uniformiter lato-clavata, et distributo geographica in Asia occidentalis-septentrionali.*

Holotype — **RUSSIA**, **Primorsky Territory**, **Khasansky Dist.**, Kedrovaya Pad Nature Reserve, N 43° 05.869', E 131° 33.572', 104 m elev., 18.VIII.2005, coll. RHP & A Kovalenko (as Xeromphalina sp.), TFB 11844 (TENN 60729).

Etymology — Denotes Kedrovaya Pad Reserve, Khasansky Dist., Primorsky Territory, Russia, type location.

Macrocharacters — Basidiomata (Fig. 2a,b) small, marasmielloid; Pileus 5–9 mm broad, shallowly convex, plane with central depression, to subinfundibuliform, outward subtly crenate-striate, appearing glabrous but unglazed, inward "Madder brown" (10E8), outward "Pompeian red" (10C6), leaching copious carmine pigment into KOH; margin sometimes subcrenate, deeply striate; Lamellae arcuate to decurrent, thick (almost fold-like), occasionally forked, near "dragon's blood red" (8C8) to deep maroon, shallow; lamellar edge minutely marginate (especially when dried: faces grayish maroon, margin minutely deep, clear maroon); Stipe 8–13 × 0.5–0.8 mm, terete, slender, tough, near "madder brown" (10E8) here and there glazed, perhaps as though with a thin viscid layer, profoundly hollow; basal pad deep cinnabar red, not widely spread, felty. 3% KOH on dried pileus turns instantly red-black; Odor none; Taste none.

Habitat — On *Alnus* catkins, *Alnus* twigs, and closely associated dead grass stems.

Microcharacters — Pileipellis with superficial, thin viscid layer; tissue of repent, radially arranged hyphae 3.5–6.5 µm diam., occasionally septate (and occasionally obscurely clamped), unornamented, thin- to firm-walled (wall never more than 0.5 µm thick), apparently hyaline. Pileus trama dextrinoid, constructed of intricately interwoven, thin- to firm-walled (wall never more than 0.5 μm thick), occasionally inflated (up to 30 μm diam.), obscurely clamped hyphae; slender (2.5–4 μm diam.), frequently branched, thin-walled, clamped hyphae occasional; vascular hyphae occasional, 4–6 μm diam., thin-walled, refringent (PhC). Lamellar trama interwoven, dextrinoid; tramal hyphae uniformly 6–7 μm diam., often asymmetrically inflated to 15 μm diam., thin-walled, conspicuously clamped; vascular hyphae rare, 3.5–5 μm diam., refringent (PhC); BASIDIA (Fig. 3a) 18–25 × 6–7 μm, digitate to narrowly clavate, clamped, 4-spored; contents with a few small, scattered guttules. Basidioles digitate, not mucronate, prominently clamped; BASIDIOSPORES (Fig. 3b) 6–8(–9) × 3.5–4 μm, ellipsoid, somewhat tapered proximally abaxially (i.e. asymmetirically lacrymoid; narrowly pip-shaped), thin-walled, hyaline, weakly amyloid; contents with 1–few, small, scattered guttules. Lamellar edge virtually sterile, a solid beard of cheilocystidia; CHEILOCYSTIDIA (Fig. 3c) 21–59 × 7–14 μm, pedicellate, broadly clavate, clamped, hyaline, thin- to firm-walled (wall never more than 0.5 μm thick), smooth (without ornamentation) or rarely with some asymmetric outgrowth. Stipe surface naked, very slightly viscid; surface hyphae 2–6 μm diam., thin-walled, conspicuously clamped, repent, probably adherent to underlying tissue; outer stipe flesh hyphae 6-11 μm diam., short-celled (cells 20–50 μm long), thin-walled, not constricted at septa, obscurely clamped, dextrinoid; surface hyphae rarely produce out-turned terminal cells; CAULOCYSTIDIA (Fig. 3d), 32–75 × 5–17 μm, very thin-walled, broadly clavate, probably clamped, hyaline or very pale pink.

CULTURE — LE(BIN) 2000. On malt extract agar mycelium covering 90 mm in 3.5 weeks. Advancing zone appressed; outline even. Mat wooly with thin, radiating hyphae, matted, mealy white with age; odor absent; reverse unchanging. Vegetative hyphae (2–)2.5–5(–5.5) μm diam. with frequent prominent clamp connections. In age, colony kept under light may form mycelial crust; interlocking hyphae form numerous swellings and round cells. Laccase reaction = ++. Culture LE(BIN) 2000 maintained in Komarov Botanical Institute Basidiomycetes Culture Collection LE (BIN) as subculture on ale-wort agar slants and in vials under distilled water.

COMMENTARY — When collected, field characters did not satisfactorily place basidiomata taxonomically. Almost all basidiomata were on *Alnus* catkins, peduncles and twigs, with only a few on closely associated dead grass stems and leaves. With decurrent, thick lamellae almost fold-like and small cinnabar basal pad, the specimens were noted as possibly *Xeromphalina*, although the deep red colors were discordant for that genus. Filamentous black rhizomorphs (now thought probably not associated with the basidiomata) further suggested *Xeromphalina*

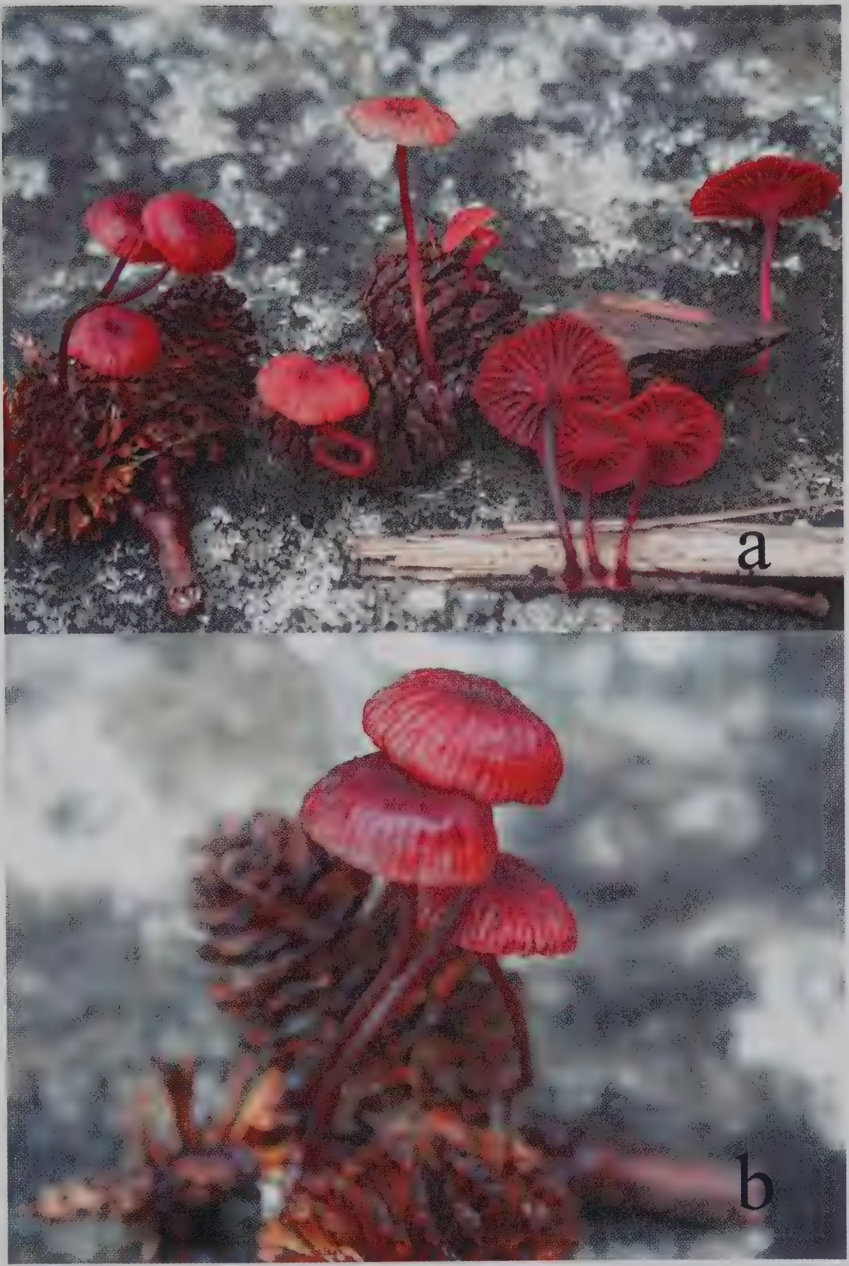

Fig. 2. *Cruentomycena kedrovayae*, basidiomata.
Holotype. a = ×3. b = ×7. Photos by A. Kovalenko.

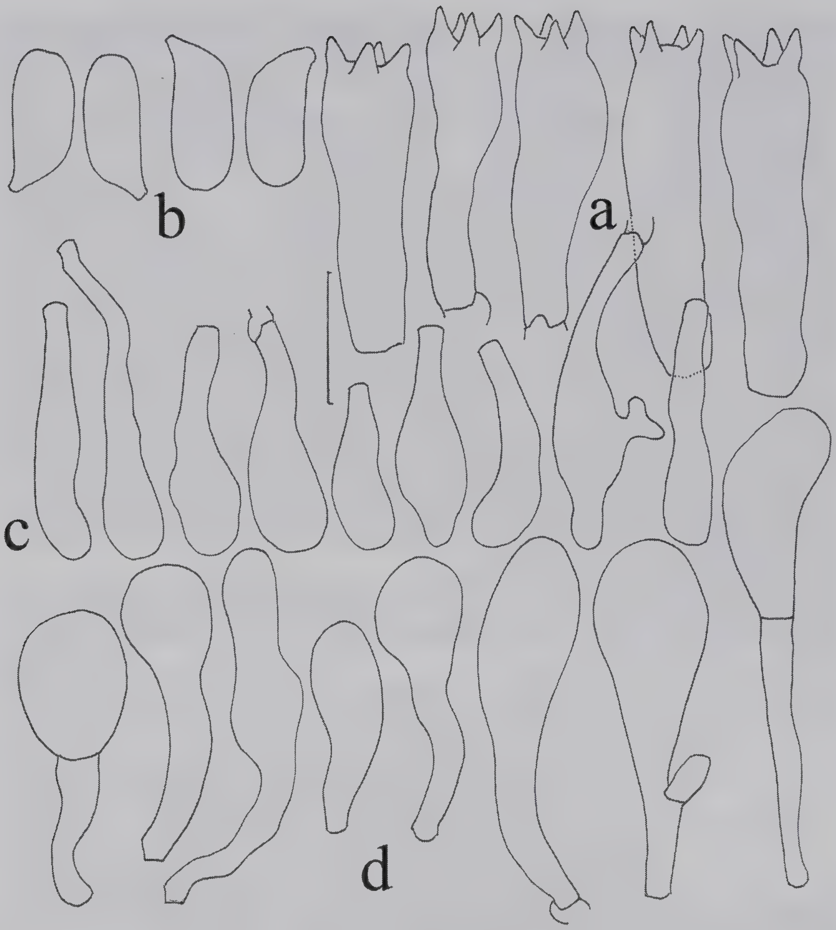

Fig. 3. *Cruentomycena kedrovayae*, holotype.
a. Basidiospores. b. Basidia. c. Cheilocystidia, d. Caulocystidia.
Standard bar = 10 µm for basidiospores and basidia; otherwise = 20 µm.

Later, ITS and LSU DNA sequences placed the collections together with *Panellus*, *Dictyopanus* and *Resinomycena* in the panelloid clade (Moncalvo et al. 2002). While internally macromorphologically anachronistic, the clade was characterized by coralloid "dendrohyphidia," especially as cheilocystidia, dextrinoid tramal tissues and amyloid spores. Basidiomata of the Russian collections failed to demonstrate the diagnostic oleocystidia and dendrohyphidia of *Resinomycena*, so placement in this genus was abandoned.

Another taxon that Moncalvo et al. (2002) placed in this clade was *Mycena viscidocruenta*. Basidiomata were diagnosed with bright red coloration, with viscid pileus and stipe surfaces. When Australian material of *M. viscidocruenta* was examined, microscopic characters similar to the Russian collections were observed and ITS sequences virtually matched those of the Russian material (2.86% base-pair difference). The collection used to generate the LSU sequence for Moncalvo et al. (2002) was a Vilgalys collection from Tasmania, and LSU sequences of the Russian collections matched that of the Vilgalys collection. We considered *M. viscidocruenta* to be a likely identity of the Russian material, at least congenerically.

In order to better understand taxonomic separation of the collections of *M. viscidocruenta* from *Resinomycena*, we examined specimens of *R. rhododendri* (typus generis) from herb. TENN. In all cases, abundant oleocystidia and coralloid hyphal termini were observed on all surfaces of basidiomata (fully described and illustrated by Redhead & Singer 1981; Redhead & Nagasawa 1987). Basidiomatal features were significantly different; slender, gracile, off-white but clitocyboid in *Resinomycena*; shorter, hardly gracile, marasmielloid and blood red in *M. viscidocruenta*. Also significant, however, was that two ITS sequences representing *R. rhododendri* were basal to sequences representing *M. viscidocruenta* collections at both ITS and LSU resolutions. At the LSU level, the placement of the single sequence of *R. acadiensis* is unexplained and an ITS sequence is unavailable for this taxon. Thus, morphologically and based on in-hand material, *M. viscidocruenta* seemed discordant in clade /panelloid. A new genus seemed necessary to accommodate *M. viscidocruenta* and the Russian collections.

Specimens examined (*Resinomycena rhododendri*) — **USA, North Carolina, Haywood Co.,** Great Smoky Mountains National Park, Cataloochee Cove, Caldwell Creek Campground, 30.VI.1989, coll. DE Desjardin, *TFB 1852* (*TENN 48598*); **Swain Co.,** Great Smoky Mountains National Park, Mingus Mill Creek Trail, 13.VII.2006, coll. E Lickey (as *Clitocybe* sp), *TFB 13275* (*TENN 61536*). **Tennessee, Blount Co.,** Great Smoky Mountains National Park, Elkmont, Jakes Creek Trail, 3.VII.1991, coll. SA Gordon, RHP, DE Desjardin, V Antonin, *TFB 3574* (*TENN 50793*); **Knox Co.,** Knoxville, Timberlake Rd., 3.VIII.1958, coll. L.R. Hesler, (*TENN 23102*).

Specimens examined (*C. kedrovayae*) — **RUSSIA, Primorsky Territory,** Khasansky Dist., Kedrovaya Pad Nature Reserve, N 43° 05.869', E 131° 33.572', 104 m elev, 18.VIII.2005, coll. RHP & A Kovalenko (as *Xeromphalina* sp.), *TFB 11844* (*TENN 60729*; holotype); same location, N 43°05.875', E 131°33.186', 18.VIII.2005, *LE212084* [culture: *LE(BIN)2000*]; same location, N 43° 05.869', E 131° 33.572', 16.VIII.2005, coll. A. Kovalenko, *TFB 11831* (*TENN 60716*).

Molecular Analyses — The results of Parsimony and Bayesian analyses of ITS and LSU data sets were consistent (Figs. 4, 5). Both analyses place *Resinomycena rhododendri* basal to *Cruentomycena* and to *Panellus stypticus* and *Panellus* (*Dictyopanus*) *pusillus*. This relationship was also noted by Moncalvo et al. (2002) who placed *R. rhododendri* basal to the panellioid clade based on ribosomal LSU sequence data.

Discussion

Collection TENN 60729 (*Cruentomycena kedrovayae*) was largely indistinguishable from collection G&R0368 [K(M): 117458] (*Cruentomycena viscidocruenta*). The bright red hyphal contents easily dissolved in water and KOH when tissue was rehydrated; spore shape was identical and spore size nearly so. Cystidial shapes were identical and included some digitate forms; pileus micromorphology was the same; pileocystidia were absent.

Resinomycena was proposed for species formerly in *Mycena*, *Marasmius* and *Omphalina* that share digitate oleocystidia and dendrohyphidioid elements over pileal and stipe surfaces, and produce amyloid basidiospores and oleiferous cheilocystidia (Redhead & Nagasawa 1987). *Resinomycena rhododendri* was characterized as having oleiferous hyphae but hyphae lack the red contents of *M. viscidocruenta*. Spores of *R. rhododendri* and *C. viscidocruenta* are similar in shape and are hyaline, amyloid and smooth. Cheilocystidia are similar in shape to those seen in *C. viscidocruenta* except that digitate cheilocystidia are seen in *C. viscidocruenta* and were not reported for *R. rhododendri*. The habitat of *R. rhododendri* and *C. viscidocruenta* is similar; leaf litter, twigs, and woody fruit husks (TENN 60729 was fruiting on *Alnus* catkins, leaf litter and twigs).

Mycena viscidocruenta sensu lato is embedded in the panelloid clade comprising *Panellus stypticus* and species traditionally within *Dictyopanus* (*D. pusillus* and *D. copelandii*) (see also Matheny et al. 2006). *Panellus pusillus* was transferred from *Dictyopanus* to *Panellus* by Burdsall & Miller (1975) based on a number of shared morphological characters including lignicolous habitat, ovoid (sometimes narrowly ovoid) amyloid spores, a basidiome with a well-developed lateral stipe, a dry cuticle of densely entangled hyphae penetrated by pileocystidia with refractive contents and bioluminescence. The proposed relationship between *P. stypticus* and *P. (Dictyopanus) pusillus* was confirmed using molecular data by Jin et al. (2001a). *Panellus stypticus* is widely distributed in Northern and Southern Hemisphere temperate forests while *P. pusillus* is tropical or subtropical. Collections of *P. stypticus* collected in Kedrovaya Pad belonged to the Asian/US Pacific Northwest clade identified by Jin et al. (2001b).

The finding of *C. kedrovayae* in temperate forests of eastern Russia produces an apparent disjunct distribution (Petersen & Hughes 2007). Lack of reports of this brightly colored species from China, Japan, southeastern Asia, Indonesia and Malaysia may be due to its absence in these geographical regions (but see Corner 1994a: 239, Pl. 23, Fig. 28, for description of *Mycena. roseilignicola* Corner). More likely, it has been collected under a different epithet, or is rare and has been missed by collectors. A number of other taxa or Asian clades of taxa share similar distributions including *Lentinula edodes* (Hibbett 1998),

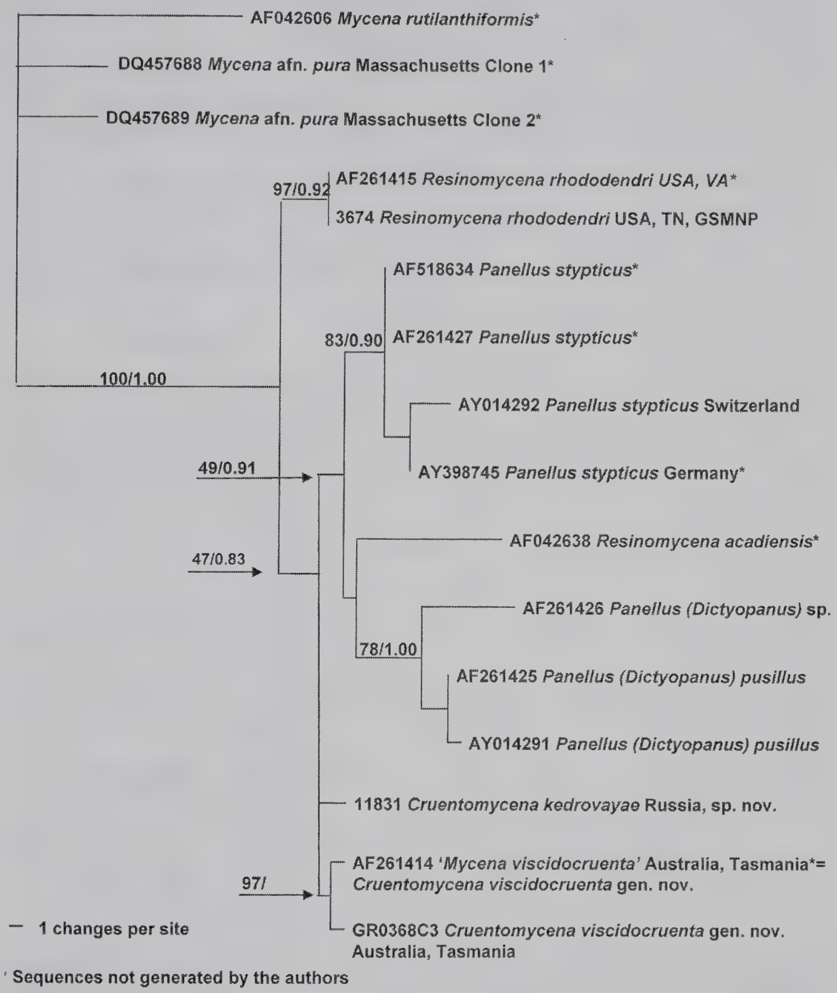
AF042606 *Mycena rutilanthiformis**
DQ457688 *Mycena* afn. *pura* Massachusetts Clone 1*
DQ457689 *Mycena* afn. *pura* Massachusetts Clone 2*
97/0.92
AF261415 *Resinomycena rhododendri USA, VA**
3674 *Resinomycena rhododendri* USA, TN, GSMNP
AF518634 *Panellus stypticus**
83/0.90
AF261427 *Panellus stypticus**
100/1.00
AY014292 *Panellus stypticus* Switzerland
49/0.91
AY398745 *Panellus stypticus* Germany*
AF042638 *Resinomycena acadiensis**
47/0.83
AF261426 *Panellus (Dictyopanus)* sp.
78/1.00
AF261425 *Panellus (Dictyopanus) pusillus*
AY014291 *Panellus (Dictyopanus) pusillus*
11831 *Cruentomycena kedrovayae* Russia, sp. nov.
AF261414 '*Mycena viscidocruenta*' Australia, Tasmania*= *Cruentomycena viscidocruenta* gen. nov.
97/
1 changes per site
GR0368C3 *Cruentomycena viscidocruenta* gen. nov. Australia, Tasmania
* Sequences not generated by the authors

Fig. 4. One of 100 trees derived from Parsimony analysis of sequences from the ribosomal ITS1-5.8S-ITS2 region (maxtrees = 100 and was not increased). Bootstrap support for 1000 trees followed by Bayesian posterior probabilities is given to the left of a node. Tree length was 182 steps. All characters were unordered and equally weighted; 391 characters were constant. 33 variable characters were parsimony-uninformative; 98 were parsimony-informative. Gaps were treated as "missing." Starting tree(s) obtained via stepwise addition. Addition sequence = furthest. Tree length = 182; Consistency index = 0.8681, Homoplasy index = 0.1319.

Panellus stypticus (Jin et al. 2001b), *Xerula globospora* (Petersen & Nagasawa 2005) and *Oudemansiella altissima* (Corner 1994b).

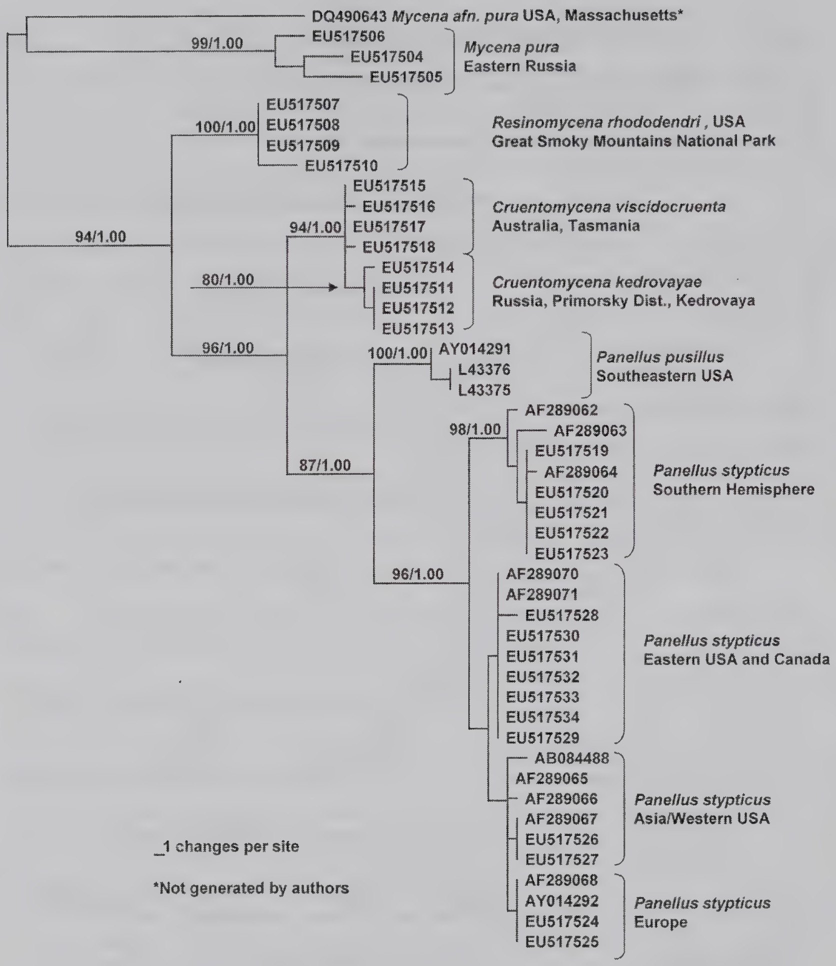
DQ490643 *Mycena afn. pura* USA, Massachusetts*
99/1.00
EU517506
EU517504
EU517505
Mycena pura
Eastern Russia
EU517507
100/1.00
EU517508
EU517509
EU517510
Resinomycena rhododendri , USA
Great Smoky Mountains National Park
EU517515
EU517516
94/1.00
EU517517
EU517518
Cruentomycena viscidocruenta
Australia, Tasmania
94/1.00
80/1.00
EU517514
EU517511
EU517512
EU517513
Cruentomycena kedrovayae
Russia, Primorsky Dist., Kedrovaya
96/1.00
100/1.00
AY014291
L43376
L43375
Panellus pusillus
Southeastern USA
AF289062
98/1.00
AF289063
EU517519
AF289064
EU517520
EU517521
EU517522
EU517523
Panellus stypticus
Southern Hemisphere
87/1.00
96/1.00
AF289070
AF289071
EU517528
EU517530
EU517531
EU517532
EU517533
EU517534
EU517529
Panellus stypticus
Eastern USA and Canada
AB084488
AF289065
AF289066
AF289067
EU517526
EU517527
Panellus stypticus
Asia/Western USA
AF289068
AY014292
EU517524
EU517525
Panellus stypticus
Europe
_1 changes per site
*Not generated by authors

Fig. 5. One of 100 trees derived from Parsimony analysis of sequences from the ribosomal large subunit gene (maxtrees = 100 and was not increased). Bootstrap support for 1000 trees followed by Bayesian posterior probabilities is given to the left of a node. Tree length was 94 steps. All characters were unordered and equally weighted; 816 characters were constant. 31 variable characters were parsimony-uninformative; 45 were parsimony-informative. Gaps were treated as "fifth-base". Starting tree(s) obtained via stepwise addition. Addition sequence = furthest. Tree length = 182; Consistency index = 0.7619, Homoplasy index = 0.2381.

The percent ITS sequence difference between Kedrovaya Pad and Tasmanian material is 3.46% when all bases are considered individually and 2.86% when indels are counted as a single event. There is no standard by which two collections can be considered different species based on ITS sequence differences but based on data for within-species variation from the Great Smoky Mountains National Park in the United States (unpub. data), a 2.86% sequence divergence usually represents different species. Additional differences including a reduced viscid deposition on stipe and pileus, only one type of cheilocystidia, slightly wider spores and the specific substrate preference of *Alnus* catkins in Kedrovaya suggests that the Kedrovayan collections may have diverged sufficiently to be separate taxonomic entities. Cleland noted that basidiomata of *C. viscidocruenta* were viscid when wet, implying that the viscid nature of *C. viscidocruenta* from Australia may be a function of environmental conditions but Kedrovayan collections were made in very wet conditions and still lacked the trait.

Acknowledgments

The authors extend thanks to curators at K and AD for expediting herbarium loans of *M. viscidocruenta.* Administration of the Far Eastern Branch, of the Russian Academy of Sciences, Vladivostok, arranged use of facilities at Kedrovaya Pad Nature Reserve, and we offer our thanks. Collections from the Great Smoky Mountains National Park were supported by NSF DEB-0338699. Thanks are due to Drs. Andrew S. Methven and D. Jean Lodge for pre-submission reviews.

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Caribbean heterobasidiomycetes:
3. British Virgin Islands

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Abstract — Seventeen species of heterobasidioid fungi belonging to the orders *Auriculariales, Ceratobasidiales, Dacrymycetales, Exidiales, Tremellales,* and *Tulasnellales* are described or reported from the British Virgin Islands. All are newly recorded from the territory. *Endoperplexa tortola* and *Heterochaete inconspicua* are described as new species. *Heterochaete tenuicula* and *Serendipita vermifera* are newly recorded from the Americas. *Ceratobasidium calosporum* is newly recorded from the Caribbean area.

Keywords — cloud forest, xerophytic forest, *Basidiomycetes*

The species recorded in this paper were collected by the author and colleagues in October 2001 during a brief visit to the islands of Guana (18°29'N, 63°33'40"W) and Tortola (Sage Mountain area, 18°28'N, 64°33'40"W) in the British Overseas Territory of the Virgin Islands. Vegetation on the former island, dry at the time of visit, is mainly xerophytic scrub and semi-natural deciduous forest, rising from the coast up to 246 m. The island is not permanently inhabited and has been the object of extensive biodiversity surveys (Lazell 2005). Vegetation in the Sage Mountain area of Tortola (near, but outside the National Park) is mainly secondary cloud forest, at around 500 m elevation, with a mix of deciduous trees.

Two previous papers in this series have dealt with species from the Dominican Republic (Roberts 2003b) and Jamaica (Roberts 2006). Apart from two unnamed *Auricularia* and *Heterochaete* species listed from Guana Island in the checklist of Caribbean fungi by Minter et al. (2001) and an initial list of Guana fungi in Lodge & Roberts (2005), no previous published references to heterobasidiomycetes from the British Virgin Islands are known.

Auriculariales

Auricularia cornea Ehrenb., in Nees von Esenbeck, Horae Phys. Berol.: 91 (1820)
= *Auricularia polytricha* (Mont.) Sacc., in Berlese & Saccardo, Atti. R. Inst. Veneto VI. 3: 722 (1885)

Specimens examined — **Guana:** north bay, on partly fallen branch, 4 Oct. 2001, D.J. Lodge (Roberts *GA803*), *K(M) 90569*; **Tortola:** sage mountain, trail to national park, on log, 6 Oct. 2001, Roberts *GA830, K(M) 90571.*

Auricularia cornea is a common and conspicuous pantropical species, distinguished by its smooth hymenium and hirsute, but unzoned pileus. In the present series of papers, the species has also been recorded from the Dominican Republic and Jamaica (Roberts 2003b, 2006).

Ceratobasidiales

Ceratobasidium calosporum D.P. Rogers,
Univ. Iowa Stud. Nat. Hist. 17: 5 (1935) Fig. 1

Specimen examined — **Tortola:** sage mountain, trail to national park, in hymenium of *Botryobasidium* sp. on fallen branch, 6 Oct. 2001, Roberts *GA869, K(M) 132766.*

Ceratobasidium calosporum is distinguished by its bisterigmate basidia, clampless hyphae, and vermiform basidiospores. Though it sometimes forms thin, effused basidiomes, it can also occur more sparsely and, as in the present collection, consist of just a few basidia-bearing hyphae. The species was originally described from North America and has not previously been reported from the Caribbean area.

Dacrymycetales

Dacryopinax spathularia (Schwein.) G.W. Martin, Lloydia 11: 116 (1948)

Specimen examined — **Tortola:** sage mountain, trail to national park, on fallen branch, 6 Oct. 2001, Roberts *GA835, K(M) 117617.*

This is a ubiquitous warm temperate and tropical species, producing conspicuous, spathulate basidiomes with single-septate basidiospores. In the present series of papers, the species has also been recorded from the Dominican Republic and Jamaica (Roberts 2003b, 2006).

Exidiales

Basidiodendron cinereum (Bres.) Luck-Allen, Can. J. Bot. 41: 1043 (1963)

Specimens examined — **Tortola:** sage mountain, trail to national park, on branch, 6 Oct. 2001, Roberts *GA858, K(M) 133082;* same details, Roberts *GA924, K(M) 132940.*

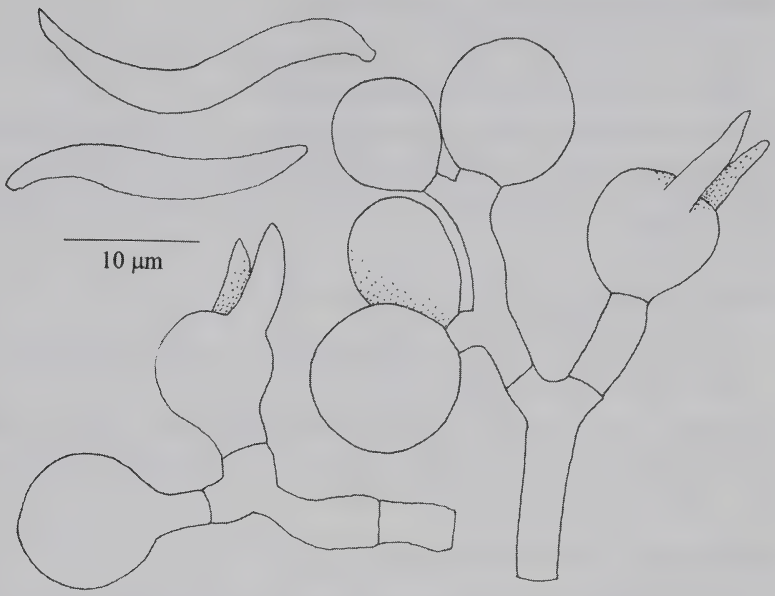

Fig. 1. ***Ceratobasidium calosporum*** (Tortola, K(M) 132766). Vermiform basidiospores; mature and immature, bisterigmate basidia arising from clampless hyphae.

Basidiodendron cinereum is a cosmopolitan species or species complex, normally producing thin, effused basidiomes with gloeocystidia and oblong basidiospores. In the present series of papers, the species has also been recorded from Jamaica (Roberts 2006).

The collection GA858 (cited above) is atypical in producing a thick, crust-like basidiome dotted with small, white tubercules. Microscopically, it has basidiospores and gloeocystidia typical of *B. cinereum*, but the hymenium also has abundant mineral matter throughout. It may well represent a distinct taxon.

Basidiodendron radians (Rick) P. Roberts, Kew Bull. 56: 170 (2001)

Specimen examined — **Tortola:** sage mountain, trail to national park, on stick, 6 Oct. 2001, Roberts *GA895, K(M) 117625.*

Basidiodendron radians is similar to *B. cinereum* (above), but produces subglobose to ellipsoid basidiospores. The species was originally described from Brazil and appears to be cosmopolitan. In the present series of papers, the species has previously been recorded from Jamaica (Roberts 2006).

Basidiodendron spinosum (L.S. Olive) Wojewoda,
Mała Flora Grzybów II: 91 (1981)

Specimen examined — **Tortola:** sage mountain, trail to national park, on fallen wood, 8 Oct. 2001, Roberts *GA908, K(M) 121613.*

Basidiodendron spinosum is a cosmopolitan species, recognized microscopically by its distinctly warted basidiospores. It was originally described from Tahiti and in the present series of papers has previously been recorded from Jamaica (Roberts 2006).

Eichleriella leveilleana (Berk. & M.A. Curtis) Burt,
Ann. Missouri Bot. Gard. 2: 744 (1915)

Specimen examined — **Guana:** iguana head, leeward trail, on fallen sticks, 5 Oct. 2001, Roberts *GA815, K(M) 90647.*

The species forms reddish, effused, stereoid basidiomes. It was originally described from North America and in the present series of papers has previously been reported from Jamaica (Roberts 2006).

Endoperplexa tortola P. Roberts **sp. nov.** Fig. 2
MycoBank 511665

Basidiomata effusa, laevia, ceracea, pallide caesiogrisea. Systema hypharum monomiticum. Hyphae agglutinatae, 1–2 µm latae, fibulatae. Hyphidia non visa. Cystidia desunt. Basidia tremelloidea, 2–4-septata, globosa vel ovoidea, 8–11.5 × 7–10.5 µm. Basidiosporae oblongae, 7–8.5 × 3.5–4 µm.

Holotype — BRITISH VIRGIN ISLANDS. **Tortola:** sage mountain, trail to national park, on dead woody stems, 6 Oct. 2001, Roberts *GA892, K(M) 132962.*

Macrocharacters — basidiomes effused, smooth, ceraceous, thin, in small patches without distinct margins, pale blue-grey drying to a thin but visible blue-grey film.

Microcharacters — hyphal system monomitic; hyphae hyaline, agglutinated and difficult to see clearly in dried material, c. 1–2 µm wide, thin-walled, with clamp-connexions; hyphidia not seen and apparently absent; cystidia absent; basidia tremelloid, 2–4-celled, globose to ovoid, 8–11.5 × 7–10.5 µm, not or scarcely stalked; sterigmata short; basidiospores oblong (Q = 1.8–2.1), 7–8.5 × 3.5–4 µm.

The genus *Endoperplexa* P. Roberts was introduced for thin, effused, exidioid species having agglutinated hyphae, small basidia with short sterigmata, hyaline cystidia, and no hyphidial layer (Roberts 1993). *Endoperplexa tortola* matches these criteria well, except for the apparent lack of cystidia. No more appropriate genus suggests itself.

The lack of cystidia distinguishes *E. tortola* from all other *Endoperplexa* species. The European *E. subfarinacea* (Hauerslev) P. Roberts additionally has rather

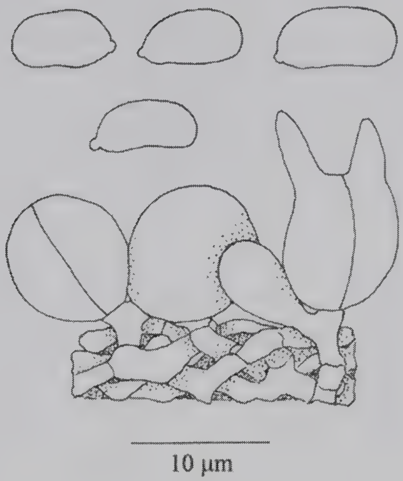

Fig. 2. ***Endoperplexa tortola*** (Holotype, K(M) 132962).
Oblong basidiospores;
mature and immature basidia arising from agglutinated, thin-walled hyphae.

more cylindrical basidiospores, whilst *E. phlebioides* P. Roberts, recently described from Belize, has basidiospores which are oblong but distinctly smaller. *Endoperplexa obscura* (G.W. Martin) P. Roberts, described from Panama, has basidiospores which are oblong and of similar size, but are subfusiform.

Exidiopsis galzinii (Bres.) Killerm., in Engler & Prantl,
Die natürlichen Planzenfamilien (2nd ed.) 6: 113 (1928)

Specimen examined — **Tortola:** sage mountain, trail near national park, on fallen decorticated wood, 8 Oct. 2001, Roberts *GA910, K(M) 117750.*

Exidiopsis galzinii is distinguished by its effused, ceraceous-gelatinous basidiomes (grey when fresh, in the collection cited above), its abundant enclosed gloeocystidia, layer of branched hyphidia, and myxarioid (stalked) basidia. The species was originally described from France, but appears to be cosmopolitan. It was redescribed and illustrated from the Dominican Republic by Roberts (2003b).

Heterochaete crassa Bodman, Mycologia 41: 531 (1949)

Specimen examined — **Tortola:** sage mountain, trail to national park, on stick, 6 Oct. 2001, Roberts GA873, K(M) 116906

Heterochaete crassa has effused, pinkish-brown basidiomes with abundant hyphal pegs, a dimitic hyphal system with skeletal hyphae predominating, and

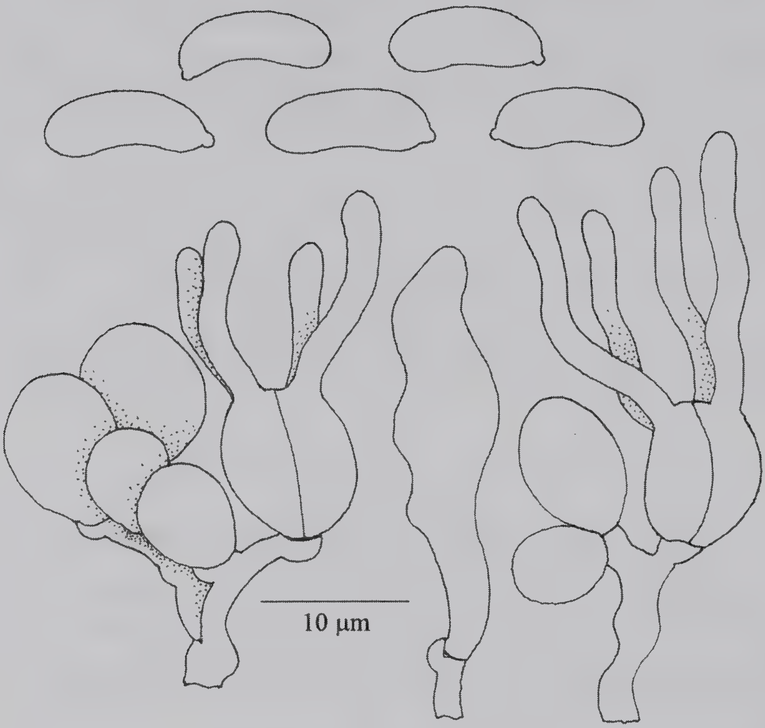

Fig. 3. ***Heterochaete inconspicua*** (Holotype, K(M) 132950).
Cylindrical basidiospores;
mature and immature basidia with an irregularly fusiform cystidium.

rather narrow, clavate basidia. It was originally described from North America and was redescribed from Jamaica and illustrated by Roberts (2006).

Heterochaete inconspicua P. Roberts **sp. nov.** Fig. 3

MycoBank 511664

Basidiomata effusa, ceracea, tenuissima, grisea, in sicco ochracea; setulis irregularis, albidis, brevis (c. 30–60 µm), c. 8–10 per mm. Systema hypharum monomiticum. Hyphae hyalinae, 2–3 µm latae, tenuitunicatae, fibulatae. Cystidia sparsa, clavata vel fusoidea, usque ad 30 × 8 µm, tenuitunicata, hyalina. Basidia tremelloidea, 4-septata, subglobosa vel ellipsoidea, 10–12 × 8–10 µm. Basidiosporae cylindraceae, 9–11 × 3.5–4 µm, suballantoideae vel allantoideae.

Holotype — BRITISH VIRGIN ISLANDS. Tortola: sage mountain, trail to national park, on dead woody stems, 6 Oct. 2001, Roberts *GA850, K(M) 132950.*

Macrocharacters — basidiomes effused, adnate, ceraceous, very thin (c. 40–50 µm thick) and visible only as greyish patches, ochraceous when dried, appearing grandinioid under lens and covered in fine, whitish, irregular and often coalescing pegs or spicules, c. 30–60 µm long, c. 8–10 per mm. Margins not distinct. Spicules sometimes tubular and discrete, sometimes amalgamating, mainly composed of agglomerated mineral matter, but interspersed with some thin-walled hyphae.

Microcharacters — hyphal system monomitic; hyphae agglutinated in a partly gelatinized matrix, hyaline, 2–3 µm wide, with thin or slightly refractive walls, with clamp-connexions; hyphidia branched, but not always seen and may break up into mineral particles at maturity; cystidia scattered and not always present, irregularly clavate to fusiform, up to 30 × 8 µm, thin-walled, hyaline or with pale yellowish contents; basidia tremelloid, septate, 4-spored, subglobose to ellipsoid, 10–12 × 8–10 µm, not stalked; sterigmata sinuous, elongated; basidiospores cylindrical (Q = 2.2–3.0), 9–11 × 3.5–4 µm, suballantoid to allantoid.

Heterochaete inconspicua is distinguished macroscopically by its thin, ceraceous basidiomes with irregularly scattered, often coalescing, small pegs or spicules and microscopically by the mainly mineral composition of these spicules, the comparatively small basidia, and the small, narrow basidiospores. When dried, the colour and grandinioid appearance may suggest a species of *Basidiodendron* Rick. The scattered cystidia are infrequent and may be absent in some mounts.

Heterochaete verruculosa (Möller) Bodman is a similarly thin, ceraceous species, but differs inter alia in its more regular hyphal pegs which are not mineralized. *Heterochaete sanctae-martae* Bodman (redescribed and illustrated in Roberts 2003) is also thin and ceraceous, but has distinctly wider basidiospores (Q = 1.8–2.2). Both these species lack cystidia.

Heterochaete shearii (Burt) Burt, Ann. Missouri Bot. Gard. 8: 377 (1921)

Specimen examined —Tortola: sage mountain, trail to national park, on partly fallen stick, 6 Oct. 2001, Roberts *GA846, K(M) 90583.*

Heterochaete shearii can be distinguished macroscopically by its effused, adnate, greyish-brown basidiomes, bruising brown, with abundant but irregular, tubular hyphal pegs, and microscopically by its brown subicular hyphae, frequent cystidia-like elements in the hymenium, and consistently bisterigmate basidia (illustrated in Roberts 2001). The species, originally described from North America, is common and widespread. In the present series of papers, it has previously been recorded from Jamaica (Roberts 2006).

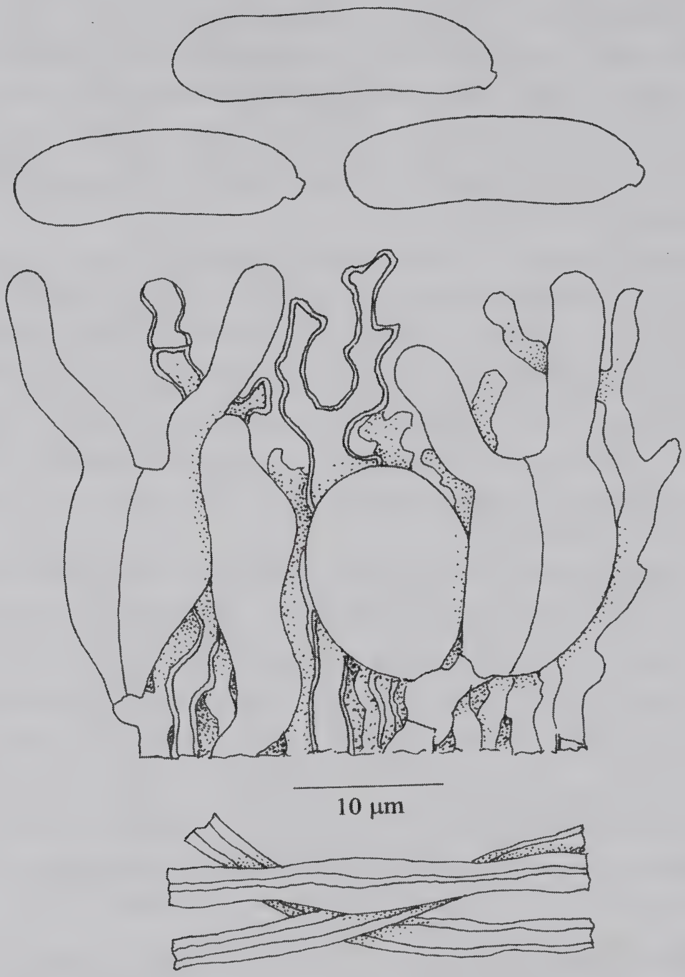

Fig. 4. ***Heterochaete tenuicula*** (Guana, K(M) 90575). Cylindrical basidiospores; section of hymenium showing mature and immature, bisterigmate basidia, an irregularly cylindrical cystidium, and branched, sometimes thick-walled hyphidia; thick-walled skeletal hyphae.

Heterochaete tenuicula (Lév.) Pat., Bull. Soc. Mycol. Fr. 10: 76 (1894) Fig. 4

≡ *Hydnum tenuiculum* Lév., Ann. Sci. Nat., Bot., sér. 3, 5: 145 (1846)

= *Hydnum delicatum* Klotzsch ex Berk. [nom. illeg., non *H. delicatum* Schwein., 1832], Ann. Mag. Nat. Hist. 3: 395 (1839)

≡ *Heterochaete delicata* Bres., Hedwigia 53: 77 (1912)

MACROCHARACTERS — BASIDIOMES effused, typically arising as circular patches which subsequently coalesce; papery and dry, cream to pale buff when fresh, pale buff when dried, with 5–8, erect, narrow, tubular, hyphal pegs per mm, the margins distinct, smooth, velvety, often reflexed.

MICROCHARACTERS — HYPHAL SYSTEM dimitic; HYPHAE in hymenium hyaline, 1.5–3 µm wide, thin- to thick-walled, with clamp-connexions; skeletal hyphae ochre-brown, 2–3.5 µm wide, thick-walled. Hyphal pegs 100–250 × 40–80 µm, arising from below the hymenial layer and mainly composed of brown skeletal hyphae; HYPHIDIA variously nodulose to branched, thin- to thick-walled; CYSTIDIA present in the hymenium as occasional clavate, cylindrical, fusiform, or irregular elements; BASIDIA tremelloid, 2-celled, oblong, 15–17 × 9–10.5 µm; STERIGMATA elongated, sinuous; BASIDIOSPORES cylindrical (Q = 3.1–3.6), some ventrally depressed, 16–21 × 5.5–6 µm, germination not seen.

SPECIMENS EXAMINED — **GUANA:** IGUANA HEAD, on partly fallen twig, 5 Oct. 2001, Roberts *GA816, K(M) 90670;* NORTH BAY, on partly fallen twigs, 9 Oct. 2001, Roberts *GA943, K(M) 90575.*

Heterochaete tenuicula is a common, pantropical species, recognizable in the field by its effused, papery, buff basidiomes with distinct, often reflexed margins, and microscopically by its two-spored basidia and brown, thick-walled, skeletal hyphae. The spores are considerably larger than those of the equally bisterigmate *H. shearii* (above). The species was originally described from Java and has not previously been reported from the Americas.

Serendipita vermifera (Oberw.) P. Roberts, Mycol. Res. 97: 474 (1993) FIG. 5

SPECIMEN EXAMINED — **TORTOLA:** SAGE MOUNTAIN, TRAIL TO NATIONAL PARK, in hymenium of *Botryobasidium* sp. on fallen branch, 6 Oct. 2001, Roberts *GA875, K(M) 132767.*

Serendipita vermifera typically forms no visible basidiomes, but is found in the hymenia of corticioid fungi (particularly *Botryobasidium* species) where it produces clusters of tremelloid basidia and vermiform basidiospores. The species was originally described from Germany and is widespread, though seldom collected, in Europe. It has not previously been reported from the Americas.

Tremellales

Tremella foliacea Pers., Obs. Mycol. 2: 98 (1800)

SPECIMEN EXAMINED – **TORTOLA:** SAGE MOUNTAIN, TRAIL TO NATIONAL PARK, on half-fallen stick, 6 Oct. 2001, Roberts *GA834, K(M) 132939.*

Tremella foliacea is a cosmopolitan species with brown, typically foliaceous basidiomes (though small and more lobate in the collection cited above). In the present series of papers, the species has been reported from the Dominican

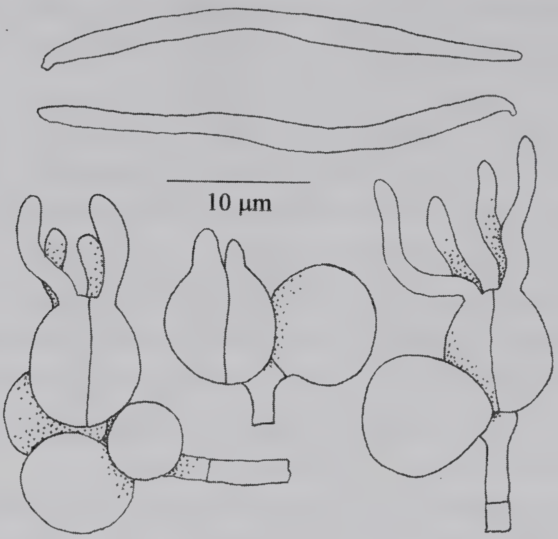

Fig. 5. ***Serendipita vermifera*** (Tortola, K(M) 132767).
Vermiform basidiospores; mature and immature basidia.

Republic (Roberts 2003b). Specimens from England were described and illustrated in Roberts (1999) and from Brazil in Roberts & de Meijer (1997). It is normally assocated with the mycelia of *Stereum* species, though no basidiomes of the latter were seen in the Tortola collection.

Tremella fuciformis Berk., Hooker's J. Bot. Kew Gard. Misc. 8: 277 (1856)

Specimen examined — **Tortola:** sage mountain, trail to national park, on dead standing pole, 6 Oct. 2001, Roberts *GA832, K(M) 90275.*

Tremella fuciformis is a common, pantropical species, originally described from Brazil and distinguished by its delicate, white, fuciform basidiomes, small basidia and basidiospores (illustrated in Roberts & de Meijer 1997). In the present series of papers, the species has been reported from Jamaica (Roberts 2006).

Tulasnellales

Tulasnella eichleriana Bres., Ann. Mycol. 1: 113 (1903)

Specimens examined — **Tortola:** sage mountain, trail near national park, on fallen wood, 8 Oct. 2001, Roberts *GA917, K(M) 117623;* same details, Roberts *GA940, K(M) 117619.*

Tulasnella eichleriana is a cosmopolitan species or species complex, originally described from Poland and redescribed and illustrated by Roberts (1994). The species can be recognized by its effused, ceraceous, grey-violaceous basidiomes, clampless hyphae, and small, subglobose to ellipsoid basidiospores. *Tulasnella eichleriana* has been recorded in the Caribbean from the Dominican Republic and Jamaica (Roberts 2003b, 2006).

Acknowledgments

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A study of lichenicolous species of *Polysporina* (*Acarosporaceae*)

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Abstract — Three lichenicolous species of *Polysporina* are recognized: *Polysporina arenacea, P. pusilla,* and *P. subfuscescens. Polysporina lapponica* is found to be a misapplied name to *P. subfuscescens*. The new combinations *P. arenacea, P. subfuscescens,* and *Sarcogyne lapponica* are made. *Sarcogyne lapponica* is reported from Norway, Sweden and Switzerland. A neotype is selected for *Sarcogyne dubia. Polysporina pusilla* is reported new for Asia (Iran, Turkey) and North America (western North America).

Key words — accession fissure, algicolous, calciphiles, carbonization, species concepts

Introduction

Polysporina (Acarosporaceae) is a small and common crustose genus occurring on acid and calcareous rock. As currently circumscribed, the genus contains 12 valid binominals (MycoBank 2008). The type species for the genus is *Polysporina simplex* (Davies) Vězda. *Polysporina* occurs in both the northern and southern hemispheres (Knudsen 2008a). The most recently described species was *Polysporina frigida* Kantvilas & Seppelt (Kantvilas & Seppelt 2006).

The main characters of *Polysporina* are a non-amyloid tholus (*Acarospora*-type ascus), polyspory (50–200 ascospores per ascus), a non-thalline margin, a carbonized exciple, and the build-up of carbonized accretions on the surface of the apothecial disc (Vězda 1978, Golubkova 1988, Kantvilas 1998, Knudsen 2008a). Vězda (1978) used the character of branching and anastomosing paraphyses in *P. simplex* to segregate the genus *Polysporina* from *Sarcogyne.* Based on our observations, branching and anastomosing paraphyses may be frequent or infrequent in the same species. Branching of paraphyses can be observed in many *Sarcogyne* species and some *Acarospora* species, particularly in *A. smaragdula* (Wahlenb.) A. Massal. The width of the apices of paraphyses also varied in our observations.

Carbonization is the build-up of pigmentation in fungal structures. In *Acarosporaceae*, the most extreme carbonization of the exciple is seen in species *Polysporina* and *Sarcogyne clavus* (DC.) Kremp., with complete death and fusion of the excipular hyphae. *Polysporina* is very close to the core group of *Sarcogyne,* e.g. *S. clavus* and *S. privigna* (Ach.) A. Massal., both of which have carbonized exciples. *Polysporina* species differ morphologically from *Sarcogyne* s. str. only in the build-up of carbonized accretions (umbos and ridges) on the apothecial surface that gives the genus its characteristic look. In early development of *P. urceolata* (Anzi) Brodo, the apothecia do not usually have carbonized accretions on the disc surface, but in other species the accreted structures are usually apparent at all stages of development of apothecia. The development of carbonization on the surface of the epihymenium, the formation of sterile columns of hyphae in the hymenium, and the vegetative division of apothecia all need further study.

Polysporina simplex has a basal position in the phylogeny of *Acarosporaceae* (Reeb et al. 2004) but more molecular analysis of *Polysporina* species is necessary because of problems with other specimens sequenced (Reeb, pers. comm.). The differing placement of *P. simplex* in the phylogeny proposed by Crewe et al. (2006) was due to the mis-determination of a specimen of *Sarcogyne clavus* as *P. simplex* (Martin Westberg, pers. comm.).

In *Polysporina* the species concepts are primarily based on size of apothecia, height of hymenium, paraphyses width, ascospore size and form, and substrate. The taxonomy of *Polysporina* is derived from the work of Magnusson (1935). Magnusson's species concepts are generally very narrow (Knudsen 2004) though occasionally as in the *Acarospora smaragdula* group his suite of characters led him to overlook other characters such as differences in thallus macrostructure (Knudsen 2008b).

This study began in a sunny wash in the southwestern Mojave Desert in California while we were out collecting lichenicolous fungi. The taxon currently known as *Polysporina lapponica* (Triebel et. al. 1991; Knudsen 2005, 2008a) is common in the Mojave Desert (Knudsen & La Doux 2005, 2006; Knudsen & Werth 2008). We wondered whether the taxon in California was the same as the taxon in the Czech Republic because the southern California specimens usually have wider (usually 2–2.5 μm) ascospores and wider (2 μm) paraphyses than the average Czech specimens with narrower (usually 1.5 μm) ascospores and narrower (1–1.5 μm) paraphyses. The ascomata of California specimens appeared larger and more superficial too.

To decide whether specimens from Europe and North America were conspecific or distinct species, we had to revise Magnusson's taxonomy. We began with an investigation of the Acharius type of *Lecidea lapponica* and then examined lichenicolous specimens from Europe, Asia, and North America.

Methods and materials

Sections were prepared by hand and examined in water, lactophenol cotton blue, 10% KOH, and I (Lugol). Reactions were tested in I and I with pretreatment with KOH (K/I). Ascospore measurements were made in water and measurements of apothecial structures in water and KOH. Values in parenthesis represent lowest or highest measurements. A new term accession fissure is used to describe the separation of apothecia during vegetative division.

Specimens were studied from ASU, B, COLO, FR, GZU, H, LE, LD, MIN, NY, PRM, S, UCR, UPS, and W.

Introductory discussion

Lichenicolous *Polysporina* are non-lichenized fungi with both endolithic and endokapylic thalli. The mycelium of the endolithic thallus occurs in the upper 1 mm of rock. It is either independent of a host, migratory from one host to another (observable as a line of apothecia between hosts), or is parasitic on the endolithic thalli of other lichens like *Lecidea laboriosa* Müll. Arg. and probably algicolous especially in the case of *P. pusilla*. The thallus when endokapylic may enter the host either through ascospores lodging on thallus or through infiltration of the host from below by the endolithic thallus.

All three taxa discussed here are not host specific, though they may be more common on one host than another in particular biotas. All three species are pathogenic, degrading the fungal host and exhausting the algal layer. Collector bias is for specimens where the host is usually intact during the early stage of infection. These specimens can also give the impression that the fungus may be a parasymbiont. But even in these specimens ascomata production has usually already been suppressed in the host.

The lichenicolous species

1. *Polysporina subfuscescens* (Nyl.) K. Knudsen & Kocourk., **comb. nov.**

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Type: **FRANCE.** COLLIURE, 1872 (H-NYL 24518, **HOLOTYPE**).

Basionym. *Lecanora subfuscescens* Nyl., Flora (Regensburg) 56: 199 (1873).

≡ *Biatorella subfuscescens* (Nyl.) H. Olivier, Bull. Acad. Intern. Geogr. Bot 11: 56 (1902).

≡ *Acarospora subfuscescens* (Nyl.) H. Magn., Rabh. Krypt.-Fl., ed. 2, 9(5:1): 146 (1935).

≡ *Sarcogyne subfuscescens* (Nyl.) Boistel, Nouv. Fl. Lichens 2: 228 (1903).

= *Acarospora silesiaca* H. Magn., Rabh. Krypt.-Fl., ed. 2, 9(5:1): 145 (1935). Type: **POLAND. Dolnoslaskie.** SWIDNICA, 1890, *Eitner* (UPS, **HOLOTYPE**).

= *Acarospora sordida* var. *urbana* H. Magn., Kungl.-Akad. Handlingar ser. 3, 7(4): 126 (1929). Type: **SLOVAKIA.** BRATISLAVA, ST. GEORGEN (SVATÝ JUR), on a stone bridge in vineyard, 21 VII 1922, *Magnusson* 6868b (UPS, **HOLOTYPE; S, ISOTYPE**).

= *Acarospora tyroliensis* H. Magn., Rabh. Krypt.-Fl., ed. 2, 9(5:1): 149 (1935). Type: **AUSTRIA.** TYROL, ALPS, hb. Zwackh (H-NYL 24560, **HOLOTYPE**).

= *Sarcogyne scabra* Nyl., Lich. Japon., p. 49 not. (1890). Type: **AUSTRIA.** TYROL, ALPS, hb. Zwackh (H–NYL 24560, **HOLOTYPE**).

= *Polysporina ferruginea* (Lettau) M. Steiner ex Kantvilas, Lichenologist 30(6): 557 (1998). Type: not seen, see discussion.

≡ *Sarcogyne simplex*. f. ferruginea Lettau, Feddes Repert. Spec. Nov. Regni Veg., 57: 73 (1955).

= *Sarcogyne bicolor* H. Magn. Ann. Crypt. Exot., 7: 130–131 (1934). Type: **USA. CALIFORNIA: Los Angeles Co.** SANTA MONICA MOUNTAINS, OCEAN BLUFFS, POINT DUME, VIII 1928, *Hasse* (FH, **HOLOTYPE**).

= *Acarospora gyrosa* N. S. Golubk., Novitates Systematicae Plantarum non Vascularium 9: 220 (1972). Type: **TADZHIKISTAN.** VOSTOCHNYJ PAMIR, MURGAB, CHECHEKTA R., 3860 m, on silicate boulder, 29 VII 1964, *Golubkova* (LE 378, **HOLOTYPE**).

= *Sarcogyne dubia* H. Magn., Rabh. Krypt.-Fl., ed. 2, 9(5:1): 72. Type: **FRANCE.** HERAULT, L'AGDE, (sur) laves, 1935, hb. J. Maheu (UPS, **NEOTYPE** designated here).

= *Polysporina sinensis* (H. Magn.) N. S. Golubk., Konspekt Flory Lishaïnikov Mongol'skoï Naradnoï Respubliki (Leningrad). p. 138 (1981). Type: **MONGOLIA.** KANSU, HEI–KU (SHARGALTEIN), 3 IV 1932, *Bohlin* 85a (S, **HOLOTYPE**).

≡ *Sarcogyne sinensis* H. Magn., Lich. from Central Asia, p. 70 (1940).

DESCRIPTION – Lichenicolous, THALLUS endokapylic or endolithic, vegetative hyphae hyaline, usually less than 1 mm diam, I–.

APOTHECIA immersed to superficial, dull black or brownish black when dry, always black when wet, round and convex to irregular, 0.3–1.0(–3.0) mm diam, usually less than 0.5 mm tall, dispersed or clustered; larger apothecia, between 1–3 mm, usually in a process of division, forming agglomerations with deep accession fissures, initially forming angular edges when division completed; disc black with accretions of carbonization in irregular structures 50–150 µm tall, with small patches of reddish smooth un-carbonized disc surface; margin fissured, rough. EXCIPULUM of narrow hyphae to 100 µm thick, especially near surface of disc, outer layer carbonized, inner layer narrow, yellowish to hyaline. HYMENIUM (80–)100–140(–180) µm tall, hyaline to yellowish-orange, often divided by sterile columns of conglutinated hyphae, usually I+ blue eventually turning red but often reaction various from red to yellow-green, epihymenium 10–15 µm thick, conglutinated in a dark brownish or reddish-brown gel. PARAPHYSES coherent, 1–2 (–3) µm diam at mid-level, sometimes various in size in same hymenium, frequently or rarely branching, sometimes thicker where branched or rarely paraphyses 2–3 µm diam mixed with narrower paraphyses, with or without oil drops, septate, rarely constricted at septa, cells 4–7 µm long, usually becoming shorter in upper third, apices barely expanded to 3 µm wide. ASCI clavate to subcylindrical, usually 50–110 × 12–20 µm, 100 to 200 ascospores per ascus, varying, sometimes with between 50–100 ascospores per ascus. ASCOSPORES (3.0–)4.0–4.5(–5.0) × (1.0–)1.5–2.0(–3.0) µm, narrowly to broadly ellipsoid. The spores varied in size, sometimes depending on amount of ascospores per ascus, both between specimens and even in same specimen. SUBHYMENIUM 20–50 µm thick, usually hyaline, sometimes reddish to golden. HYPOTHECIUM (20–)30–45 µm thick, of narrow hyaline prosoplectenchyma, ca. 0.5–1.0 µm diam, forming often uneven border in thallus of host, confluent with vegetative hyphae, and often appearing much deeper but actually indistinguishable from vegetative hyphae infiltrating host from below. CONIDIOMATA not observed.

ECOLOGY AND SUBSTRATE – Appearing to prefer sunny open habitats, on various crustose hosts including species of *Acarospora, Buellia, Caloplaca, Candelariella*, and *Lecidea* on usually siliceous rock.

DISTRIBUTION – North America, Europe, Asia, in the northern hemisphere, up to 1869 m.

DISCUSSION – *Polysporina subfuscescens* is a widely distributed and successful parasitic fungus. It is an aggressive parasite, suppressing ascomata production of host, and eventually depleting algal layer and destroying the host, dissolving the stratified lichen structure and reducing it to a clumps of ecorticate white gelatinized hyphae. Then the ascomata of the parasite eventually atrophy.

Polysporina subfuscescens infects the host in two ways. Firstly, the ascospores can lodge on the host. The excipulum of the ascomata in an early stage of infection forms a distinct and narrow hypothecium in the thallus of host and vegetative hyphae are often scant. Secondly, the hyphae of *P. subfuscescens* can infiltrate the thallus of host from below forming an extended structure beneath the apothecium that can be mistaken for a deep hypothecium.

The endolithic thallus of *Polysporina subfuscescens* may be partially lichenized as a few lichenized algal cells are sometimes found in rock substrate or these may be remnants of a parasitized endolithic thallus of a saxicolous lichen.

Though our investigation began with the hypothesis that there were two taxa, the observed variation was wider in ascomata size, height of hymenium, paraphyses width, and ascospore size than in earlier descriptions (Magnusson 1935, Vězda 1970, Kantvilas 1998). The branching of paraphyses was also varied from frequent to infrequent. We found no apparent regional distribution of any variation either. Thus we agree with Triebel's broad concept of the taxon (Triebel et al. 1991).

Since the name *Polysporina lapponica* was misapplied to this taxon (see Excluded Species below), the earliest name we found for this taxon was *Lecanora subfuscescens* and a new combination in *Polysporina* is proposed.

The synonyms proposed were generally treated by the authors as different species or infraspecifc taxa based on the misconception that the thallus of host is the thallus of the lichenicolous fungus.

The exception was that *Sarcogyne dubia* (Magnusson 1935) was recognized as a lichenicolous fungus. The original circumscription of the species differs completely from that of Vězda (1970). Based by Magnusson (1935) on a single collection from South France collected by de Crozals in the herbarium of Bouly de Lesdain, it differed in having fifty ascospores per ascus, all 3 µm wide, and with no description of branching paraphyses. This specimen was apparently originally included in *Acarospora lapponica* (Ach. ex Schaer.) Th. Fr. (Magnusson 1929). The holotype could not be located and is presumed lost during World War II. A neotype from South France is selected here. It is actually quite similar to the variation of some specimens from California and Bulgaria with most ascospore widths between 2–3 µm and with occasional asci with 50–100 ascospores per ascus.

Using the narrow concepts inherited from Magnusson, Kantvilas (1998) recognized *Polysporina ferruginea* as separate from his concept of *P. lapponica* but specimens examined by us did not differ from other specimens of *P. subfuscescens*. We are unsure of the status of the holotype, but base our synonymization on an excellent paratype collected by Lettau and annotated by Steiner from B.

The holotype of *Polysporina sinensis* is definitely a lichenicolous fungus occurring on the thallus of a crustose lichen (see drawing in Golubkova 1988). The holotype was too scant to dissect. Magnusson writes "Spores at least 50, 5–7 × 3 µm." We are skeptical of Magnusson's measurements based on our experience of examining his species described from specimens from expeditions and include the name as synonym of *P. subfuscescens* based on other specimens seen from Asia. Other specimens determined by Magnusson (1940) as *P. sinensis*, however, belong to a lichenized taxon that will be treated in a forthcoming publication.

We did not see types on which the following names are based but assume they are synonyms based on the literature (Magnusson 1935): *Acarospora lapponica* var. *silesiaca* H. Magn., *Acarospora sordida* Wedd. [*Acarospora subfuscescens* var. *sordida* (Wedd.) H. Magn.], *Acarospora sordida* var. *lojkeana* H. Magn., *Lecidea simplex* var. *chloroclinella* Wedd., *Sarcogyne scabra* var. *canasiacensis* Hue [*Sarcogyne canasiacensis* (Hue) H. Magn., *Biatorella canasiacensis* (Hue) H. Olivier], *Sarcogyne simplex* var. *parasitica* de Lesd., and *Sarcogyne simplex* var. *crustosa* H. Magn. We believe *Acarospora sernanderi* H. Magn. is also a synonym but both types we saw were inconclusive (S!, UPS!) *Sarcogyne sphaerospora* J. Steiner is another probable synonym.

Since it is impossible to distinguish *Polysporina subfuscescens* and *P. simplex* using apothecial and ascospore measurements, overt signs of parasitism are used primarily to distinguish them. In difficult specimens, one must first ascertain if the *Polysporina* is lichenized or not. If there is no distinct algal layer beneath the apothecia, scratching away the top layer of the surrounding rock substrate and observing a well-developed layer of lichenized algae in a hyphal matrix, is the easiest way to determine *P. simplex.*

SELECTED SPECIMENS EXAMINED – **BULGARIA.** EASTERN RODOPI MOUNTAINS, KARDŽI, KALOJANCI, PROTECTED AREA, CA. 5 KM SW OF THE VILLAGE, 41°37'N, 25°31'E , 500 m, on crustose lichen on acid vulcanite stones on north-facing slope, 15 VIII 2004, *Vondrák 1999* (CBFS); SANDANSKÍ DISTR., IN RIVER VALLEY OF SANDANSKA BISTRICA, 400 m, on brown crustose lichen, 29 V 1968, *Vězda*, Lichens Selecti Exsiccati 693 (H); **CZECH REPUBLIC. Bohemia.** 300 m, on *Acarospora* species on sandstone, 1926, *Servít* (UPS); **West Bohemia**, KOMOTAU, 1930, *Servít* (UPS); **Central Bohemia.** PRAHA, SUCHDOL, PROTECTED AREA SEDLECKÉ ROCKS, OUTCROPS ABOVE VLTAVA RIVER, 270 m, on *Acarospora fuscata* on proterozoic shale, 13 X 2002, *Kocourková* (PRM 907503, 907542); PRAHA, KLUKOVICE, PROKOPSKÉ VALLEY, ŠPIČÁK HILL, ABOVE FORMER MILL, on top of steep west-facing calcareous cliff, 265 m, on *Acarospora fuscata* on quartz, 17 XI 1999, *Kocourková* (PRM 909497); PRAHA, MALÁ OHRADA, ALBRECHTŮV HILL BY PROKOPSKÝ BROOK, 300 m, on *Acarospora fuscata* on diabase, 23 IX 1999, *Kocourková* (PRM 90949); PRAHA, NOVÁ VES, PROKOPSKÉ VALLEY, HEMROVY ROCKS, on southwest-facing slope below steppe, 265 m, on *Acarospora fuscata* on diabase, 6 XI 1994, *Kocourková* (PRM 909499); PRAHA, ŘEPORYJE, DALEJSKÉ ÚDOLÍ VALLEY, ABOVE TRUNEČKŮV MLÝN, 265 m, on *Acarospora fuscata* on diabase, 6, XI. 1994, *Horáková* (PRM 909500); PRAHA, MALÁ CHUCHLE, BRÁNICKÝ BRIDGE, 220 m, on crustose lichen on diabase rocks, 3 IV 1988, *Horáková* (PRM 887565); DISTR. RAKOVNÍK, KŘIVOKLÁTSKO PROTECTED LANDSCAPE AREA, BETWEEN NEZABUDICE AND ROZTOKY VILLAGES, NEZABUDICKÉ SKÁLY NATURE RESERVE, AT NORTH MARGIN ABOVE BEROUNKA RIVER, on steep southwest-facing slope, in thin scree oak forest, 50°01.435'N, 13°50.689'W, 390 m, on *Acarospora fuscata* on schist, 16 II 2007, *Kocourková* & *Kocourek* (PRM 896204); **Eastern Bohemia.** HUMPOLEC, ABOVE THE VILLAGE OF KRASOŇOVÁ, 630 m, parasitic on *Acarospora fuscata, A. sinopica* & *Buellia sororia*, 9 V 1968, *Vězda*, Lichenes Selecti Exsc. 693 as *Acarospora subfuscescens* (PRM 665345, S); 9 V 1968, *Vězda*, Lichenes Selecti Exsc. 694 as *Sarcogyne dubia* (PRM 665343, H, S); **Moravia.** MOHELNO, IN VALLEY OF RIVER JIHLAVKA, on crustose lichen on serpentine, 1926, *Suza* (UPS); **DENMARK. North Jutland.** SKAGEN MUNI, KATBAKKER SW OF KANDESTEDERNE, DISTRICT 1, 15 V 1992, *Svane* 9034–1 (UPS); RÅBJERG STENE, SW OF KANDESTEDERNE, DISTRICT 1, on crustose lichen on pebbles, 31 III 1977, *Svane 506* (COLO); **GREENLAND.** GODHAVEN, AT THE ARCTIC STATION, 69°15'N, 53°32'W, 12 m, 28 VII 1952, *Gelting 18736c* (UPS); **HUNGARY.** IN VILLAGE SAJÓKERESZIUR, 125 m, on roof, 5 IV 1932, *F. Fóriss,* Lichenes Bükkenses Exsic. 92, det. Magusson as *Acarospora subfuscescens* (H, PRM 693682); **GERMANY. Hessen.** TAUNUS, NW OF LANGTAL AT NEU ANSPACH, in thin oak forest SW-exposure, 480 m, on brown crustose lichen on gneiss, 12 V 1993, *Schöller 340* (FR); WETTERAU, 150 m, on sandstone, 8 V 1993, *Schöller 302* (FR); ERZGEBIRGE, ALTENBERG, 740 m, on brown crustose lichen on basalt, 17 VII 1928, *Schade 2132* (UPS); **IRAN.** KHOY, airport, 38°25'16" N, 44°54'05" E, on *Caloplaca transcaspica* on siliceous rock, 2 V 2007, *Vondrák 5837* (CBFS); **JAPAN?** 1850, as *Sarcogyne scabra*, Herb. Zwackh (S); **NORWAY. Møre og Romsdal.** NORDAL HD., GRÖNNINGSÄTER, 350 m, on brown crustose lichen on stone fence, 7 IX 1947, *Magnusson 20778* (UPS); **Rogaland.** NORTH OF HAUGESCUND, on crustose lichen on slate roof near road, 3 VIII 1939, *Magnusson 16916* (H, S, UPS); **Oppland.** LOM PARISH, THE GLITTERTIND AREA, ICE-CORED MORAIN OF GRÅSUBREEN, 1950 m, on crustose lichen on boulders, 11 VIII 1963, *Santesson 16270* (UPS); **MEXICO. BAJA CALIFORNIA NORTE:** ARROYO 1 KM N OF CATAVIÁÑA, 29°43' N, 114°40'W, 560 m, parasitic on either endolithic lichen or remains of unknown host, 6 I 1989, *Egan 13918* (MIN); **BAJA CALIFORNIA:** 3 KM WNW OF LAGUNA CHAPALA, ON MOUNTAIN SLOPE AT BORDER OF LOWER COLORADO VALLEY, 29°27' N, 114°25'W, 780 m, parasitic on remains of unknown host, 6 I 1989, *Wetmore 63815* (MIN); **POLAND.** TATRA MOUNTAINS, 1800 m, 10 X 1956, *Vězda* (UPS); **ROMANIA.** ARAD, NADLAC, NEAR THE RAILWAY STATION, 46°09'N, 20°47'E, on *Acarospora nitrophila* on iron-rich pebbles, 5 VIII 2004, *Vondrák 2134* (CBFS); **SPAIN. Barcelona.** MONTES MONTSENY, COLFORNIC, 1100 m, 28 V 1983, *Hladun, Poelt & Vězda* (B); **SWEDEN. Bohuslän.** NORUM, ST. ASKERÖN, NEAR THE MILL, on brown crustose lichen on roof tile, 1922, *Magnusson* (UPS); PAR. STENKRYA, TJÖRN, OLSNÄS, C. 250 M ESE OF HOLMESLÄTT, 1 m, on brown crust on silicate seashore rocks, 29 VI 2006, *Westberg 06–033* (LD); **Närke.** PAR. GÖTLUNDA, ISL. VALEN (IN LAKE HJÄLMAREN), 59°15' N, 15°45'E, 25 m, on brown crustose lichen on old roofing tile, 16 X 1993, *Foucard & Nordin* (UPS); **Torne Lappmark.** NEAR TORNE TRÄSK, 29 VII 1921, *Magnusson 6023* (UPS, some duplicates *P. simplex* in other herbaria); **Västergotland.** PAR. FÄSSBERG, MÖLNDAL, LACAREBÄCK, ABOVE INDUSTRIAL AREA, 93 m, on siliceous rock outcrops, 29 VI 2006, *Westberg 06–012* (LE); **SWITZERLAND.** TOP OF NIESEN (AT THUNNER LAKE), 2266 m, on shale rock, 1 IX 1917, *Lettau* (B, **PARATYPE**); **USA. ARIZONA: Apache Co.** PETRIED FOREST NATIONAL PARK, 34°49'30"N, 109°49'00"W, 1740 m, on *Candelariella rosulans*, 14 V 1990, *Davies 724* (ASU); **CALIFORNIA: Los Angeles Co.** SANTA MONICA MOUNTAINS, TOPANGA CANYON ED EDELMAN PARK, mixed chaparral with coastal sage scrub, 34°07'19"N, 118°35'09"W, 375 m, on sandstone, 15 VIII 2004, *Knudsen 1552* w/ *Sager* (UCR); SANTA MONICA MOUNTAINS, LEO CARRILLO STATE PARK, TRAIL ABOVE WILLOW CREEK, *Adenostoma fasciculatum* chaparral, 34°03'50"N, 118°54'56"W, 499 m, on remains probably of *Acarospora oligospora*, 12 XI 2005, *Knudsen 4356* w/ *Werth, Sagar & Heinrich* (UCR); **Riverside Co.** MENIFEE HILLS WILDOMAR, *A. fasciculatum* chaparral, 33°37'19"N, 117°12'27"W, 590 m, on *Aspicilia*, 16 III 2006, *Knudsen 5366* (UCR); SAN JACINTO MOUNTAINS, SAN BERNARDINO NATIONAL FOREST, FORBES RANCH ROAD, *Adenostoma sparsifolium* chaparral and manzanita, 33°40'25"N, 116°36'45"W, 1651 m, on other lichens and crumbling granite, 26 III 2006, *Knudsen 5702* (UCR); LITTLE SAN BERNARDINO MOUNTAINS, EUREKA PEAK, JOSHUA TREE NATIONAL PARK, E AND W OF SUMMIT, pinyon pine, *Quercus john-tuckeri*, with various shrubs and perennials, 34°01'57"N, 116°21'01"W, 1675 m, on rock, 22 II 2006, *Knudsen 5187* w/ *Muertter, La Doux, Latman & Lee* (UCR); SAN JACINTO MOUNTAINS, BETWEEN CAHUILLA VISTA AND PINYON FLATS, juniper woodland, 33°35'08"N, 116°25'51"W, 1200 m, on lichen on granite, 10 XII 2004, *Knudsen 2051* w/ *Griffith* (UCR); **San Bernardino Co.** JOSHUA TREE NATIONAL PARK, KEYS RANCH, INDIAN COVE, yucca, cacti, scattered scrubs and pinyon pine, 34°02'52"N, 116°10'07"W, 1260 m, on lichen on granite, 31 III 2005, *Knudsen 2602* w/ *La Doux, Pietrasiak & Babich* (UCR); GRANITE MOUNTAIN, SWEENEY GRANITE MOUNTAIN RESERVE, CANYON ABOVE YUCCA BAJADA CAMP, desert riparian and scrub, 34°48'52"N, 115°38'37"W, 1237 m, on lichen on shale or mudstone, 12 XII 2006, *Knudsen 7982* (UCR); JOSHUA TREE NATIONAL PARK, BELLE MOUNTAIN, rocky slope with annuals, 34°00'05"N, 115°59'56"W, on granite, 22 VIII 2005, *Knudsen 3605* w/ *La Doux, Galvin* (UCR); SAN BERNARDINO MOUNTAINS, SAN BERNARDINO NATIONAL FOREST, CACTUS FLATS, EAST OF SMARTS RANCH ROAD, pinyon pine, juniper, 34°18'27"N, 116°47'27"W, 1869 m, on *Acarospora strigata* on granite, 7 VI 2005, *Knudsen 3327B* w/ M. Knudsen (UCR); **San Diego Co.** ANZA BORREGO STATE PARK, YAQUI PASS, ENCELIA, 33°08'48"N, 116°20'43"W, 550 m, on lichens on granite, 28 IV 2006, *Knudsen 5904* w/ *Muertter* (UCR); POINT LOMA, CABRILLO NATIONAL MONUMENT, POINT LOMA ECOLOGICAL PRESERVE, coastal sage scrub, 32°40'18"N, 117°14'29"W, 116 m, on *Acarospora* species on sandstone, 15 V 2007, *Knudsen 8429.1* (UCR); **Santa Barbara Co.** SANTA CRUZ ISLAND, CHANNEL; ISLANDS NATIONAL PARK, ON RIDGE EAST OF CHINESE HARBOR, grassland and coastal sage scrub, 34°00'46"N, 119°35'31"W, 368 m, on thallus of *Lecidea fuscoatra*, 12 VI 2007, *Knudsen 8523* w/ *I. M. & F. Brodo, Baguskus & Chaney* (UCR); **CONNECTICUT: Windam Co.** TOWN OF WINDHAM, W OF WINDHAM AIRPORT, SSW OF MANSFIELD HOLLOW DAM, MANSFIELD HOLLOW STATE PARK, ca. 100 m, *Cladonia* dominated gravel barren, artificial talus slope of dam, and outwash area below dam, 28 VII 2002, *Harris 46218* (NY); **COLORADO: El Paso Co.** 38.7277 °N, 104.3831°W, 1725 m, locally common on *Caloplaca*, 4 X 2007, *Morse 15885* w/ *Ladd* (KANU); **Weld Co.** NORTHWEST OF RAYMER, 91 m, *Shushan & Higgins S5647* (COLO); **KANSAS: Washington Co.** S END OF WASHINGTON CO. LAKE, 39.9209°N, 97.1176°W, 427 m, 27 I 2008, *Morse 16250* w/ *Logan* (KANU); **MICHIGAN: Washtenaw Co.** OLD FIELDS NE OF CROOKED LANE, 4 VII 1976, *Harris 11647* (COLO); **MINNESOTA: Yellow Medicine Co.** E GRANITE FALLS, UPPER SIOUX AGENCY STATE PARK, *Celtis-Quercus-Tilia* forest, 44°44'02"N, 95°27'46"W, 290 m, on boulder, 5 IX 2006, *Morse 14154A* (UCR); **NEW YORK: Clinton Co.** POINT AU ROCHE STATE PARK, 21 V 2007, old fields, calcareous slate beach with glacial erratic, and northern hardwoods with *Thuja*, initially on *Acarospora*, *Harris 53721* (NY); **PENNSYLVANIA: Bucks Co.** RALPH STOVER STATE PARK, SOUTHEAST CORNER OF PARK, BELOW STATE PARK ROAD, 82 m, extensive sandstone/ shale outcrops along creek, and shaded boulders in mixed hemlock – hardwood forest, on thallus of *Caloplaca oxfordensis* on rock in stone wall, 15 IX 2007, *Lendemer 9705* w/ *Moroz* (NY).

2. ***Polysporina arenacea*** (H. Magn.) K. Knudsen & Kocourk., **comb. nov.**

MycoBank MB 511742

Type: **USA. UTAH:** EKKER'S RANCH, 1828 m, on dry exposed, red sandstone, V 1951, *Flowers* 366 (UPS, HOLOTYPE; MIN, ISOTYPE).

Basionym. *Acarospora arenacea* H. Magn., Acta Hort. Götoburg. 19 (2): 33 (1952).

DESCRIPTION – THALLUS endokapylic or endolithic, vegetative hyphae hyaline, mostly 2–3 μm diam, septate, cells 2–5 μm long, usually penetrating host from below.

APOTHECIA superficial on host, brown when dry or wet, 0.7–1 mm diam, to 1 mm tall, round or irregular, dispersed or contiguous, forming clusters of apothecia divided by accession fissures to 3 mm wide; disc brown, convex, with furrows, ridges, and umbos, rough and uneven, margin distinct but becoming fissured. EXCIPULUM to 100 μm thick, hyphae mostly 2–3 μm diam, septate, cells mostly 2–3 μm wide, ending in expanded apices forming outer wall of the excipulum; outer layer reddish-brown, 20–30 μm thick; inner layer hyaline. HYMENIUM 80–120 μm tall, hyaline, I+ deep blue, epihymenium 10–20 μm thick, in reddish brown gel, accretions on surface of disc to 200 μm high, PARAPHYSES coherent, (1–)2–3 μm diam, septate, cells 5–7 μm long, shortening in upper third, sometimes constricted at septa, infrequently branching in lower half, unexpanded or expanded apices sometimes in darker pigment caps. ASCI 60–90 × 12–20 μm, ascospores mostly 100 per ascus. ASCOSPORES hyaline, simple, (3.0–) 4.2–4.4(–7) × 2.0–3.0 μm, mostly broadly ellipsoid. SUBHYMENIUM hyaline, 30–50 µm thick. HYPOTHECIUM 10–20 µm thick, continuous with vegetative hyphae. CONIDIOMATA not seen.

ECOLOGY AND SUBSTRATE – On crustose lichens on granite, sandstone, shale or volcanic rock in open sunny habitats.

DISTRIBUTION – Western North America (California, North Dakota, Utah) from 40–1828 m.

DISCUSSION – *Polysporina arenacea* is the only species in the genus with distinctively brown ascomata. Otherwise, its characters overlap with the upper range of variation in *P. subfuscescens.* We retain the species and transfer it from *Acarospora* to *Polysporina.*

SPECIMENS EXAMINED – **USA. CALIFORNIA: San Bernardino Co.** GRANITE MOUNTAINS, SWEENEY GRANITE MOUNTAINS RESERVE, SIBYL ALLISON TRAIL, pinyon pine and juniper woodland with chaparral, 34°47'21"N, 115°40'18"W, 1692 m, on unknown host on granite, 14 XII 2006, *Knudsen 8055* w/ *Muertter* (UCR); JOSHUA TREE NATIONAL PARK, BELOW BELLE MOUNTAINS IN UN-NAMED WASH, annuals and cacti, 34°01'08"N, 116°00'09"W, 1182 m, on unknown host on granite usually suppressing ascomata production of the host, 22 VIII 2005, *Knudsen 3620* w/ *La Doux* & *Galvin* (UCR; PRM); **Santa Barbara Co.** SANTA ROSA ISLAND, CHANNEL ISLANDS NATIONAL PARK, SOUTH SLOPE OF SOUTH PEAK, 33° 54' 23" N 120° 7' 42" W, 243 m, on *Lecidella* species and independent on shale, 15 VIII 2007, *Knudsen 8762.2* w/ *Chaney* & *Werth* (UCR); **San Luis Obispo Co.** SAN SIMEON, SAN SIMEON STATE PARK, MOLINARI PROPERTY, NEXT TO RAVINE ALONG OLD HIGHWAY ONE DIRT ROAD, on exposed slab of volcanic rock 35° 36' 14" N 121° 7' 39" W, 41 m, on unknown host, 8 I 2007, *Knudsen 8116* (UCR); **NORTH DAKOTA:** THEODORE ROOSEVELT NATIONAL PARK, NORTH UNIT, JUST EAST OF EDGE OF GLACIAL OUTLOOK, 47° 37' 04" N 103° 25' 04" W, 670 m, on unknown white crustose lichen, 23 VI 1998, *Wetmore 80113* (MIN).

3. ***Polysporina pusilla*** (Anzi) M. Steiner ex Kantvilas, Lichenologist 30(6): 558 (1998).

Type: **ITALY.** IN VALLE DI FÒREOLA SUPRA POSCHIAVO, ad rupem calcaream, in termino arboreo, (Lich. Rar. Langob. Exs. No. 190) Type: not seen.

Basionym. *Sarcogyne pusilla* Anzi, Comment. Soc. Crittog. Ital. 1(3): 157 (1862).
= *Biatorella pusilla* (Anzi) Zahlbr. ex Beck, Annal. Naturhist. Hofmuseum Wein. IV: 355 (1889).

DESCRIPTION – Lichenicolous. THALLUS endolithic or endokapylic, vegetative hyphae hyaline, 2–3 µm wide, cells 4–9 µm long, I–.

APOTHECIA round, dispersed, immersed or superficial on hosts, or immersed, emergent or sessile in rock, not apparently dividing vegetatively, mostly 0.2–0.5 (–1.0) mm diam, disc black, carbonized with umbos or ridges and furrows, or without carbonization and reddish when wetted with water, occasionally white with pruina or crystals from substrate; margin progressively rugulose with umbos, ridges and furrows. EXCIPULUM carbonized in outer layer, hyaline to black in inner layer, 40–100 µm thick, continuous with the hypothecium which can be 100–150 µm thick, which is continuous with vegetative hyphae. HYMENIUM (85–)100–125 µm tall, hyaline, conglutinate (becoming lax in K), PARAPHYSES mostly (1.5–)2.0 µm diam, rarely paraphyses wider to 2.5–3.0 µm diam, usually mixed with thinner paraphyses, infrequent to frequent branching, apices unexpanded or expanded to 3 µm diam, occasionally with pigment hoods when epihymenium surface is carbonized. Epihymenium 10–25 µm thick, dark brown, in conglutinate pigment layer reddish-brown or blackish, partially dissolving in K. ASCI 65–100 × 17–25 µm. ASCOSPORES 100–200 per ascus, usually 4.0–5.0 × 2.0–3.0 µm, ellipsoid to broadly ellipsoid. SUBHYMENIUM 20–50 µm thick. HYPOTHECIUM confluent with vegetative hyphae. CONIDIOMATA not observed.

ECOLOGY AND SUBSTRATE – In open and sunny montane habitats on calcareous rock, apothecia immersed or superficial, parasitic on *Acarospora strigata*, *Caloplaca* species, and *Protoblastenia incrustans* and probably algicolous.

DISTRIBUTION – Asia (Iran, Turkey), Europe, North America (California, Nebraska, North Dakota), from 640 to 2800 m.

DISCUSSION – *Polysporina pusilla* was originally recognized as a lichen. We recognize it as a lichenicolous fungus with an endolithic and endokapylic thallus. It produces apothecia immersed or superficial on a host or independent of at least a visible host. We have a broad concept of the species recognizing the apothecia may be as large as 1 mm diam in nutrient-rich habitats and that apothecia are be produced in pits in limestone or on surface of rock depending on probable substrate conditions. We do not recognize it as host specific but it is a calciphile. It is distinguished from *P. subfuscescens* in being a strict calciphile and having generally thicker (2–3 vs. 1–2 µm diam) paraphyses and wider (2–3 µm vs. 1.5–2.5 µm) ascospores though it overlaps with higher range of *P. subfuscescens.* It differs from *P. arenacea* in being a calciphile and having black apothecia but is similar in paraphyses diameter and ascospore width. As in *P. subfuscescens* and *P. arenacea* the endolithic thallus may be parasitic on endolithic lichens or even fungi and probably on free-living algae and can migrate through substrate to new lichen hosts. Interestingly the best-developed specimens seen during these studies were from collections by the C. Wetmore (MIN) and often appeared to be non-lichenicolous. In these specimens on large-grained limestone in Nebraska and North Dakota there were abundant free-living algae throughout upper 1 mm of the rock.

Like the lichenized *Polysporina urceolata, P. pusilla* sometimes has a non-carbonized disc surface in early ontogeny. Apparently in both species carbonization of epihymenium is the continuation of the carbonization of the excipulum and is a progressive development, usually beginning with umbos on surface of apothecia and continuing with the formation of ridges and furrows until it is similar to other *Polysporina* species.

The species can be confused with the related lichenized species *Polysporina urceolata*. They have similar spore and paraphyses sizes, but *P. urceolata* usually has a lower hymenium that is 50–60 µm tall (although in some specimens it may be taller), overlapping the height of the hymenium in *P. pusilla*. Because *P. pusilla* is a parasite, the algal layer of the host may remain for awhile, and some specimens can only be determined through the structure of the vegetative hyphae penetrating host from below forming a deeper structure confluent with the hypothecium.

The species is reported new for Asia (Iran, Turkey) and North America.

SPECIMENS EXAMINED – **AUSTRIA. Tirol.** ALPS, 1800 m, 20 VIII 1871, *Arnold* (hb. J. Suza, PRM 580306, No. 465, Anzi Exs. 190, H); 1900 m, on dolomite, 23 VII 1867, *Arnold* (No. 361, Anzi Exs. 190, FR); hb. A. Metzler (FR 9288); S-FACING SLOPES OF GATSCHKOPFES ABOVE AUGOBURG MOUNTAIN COTTAGE, NW OF LANDECK, c. 2800 m, immersed in limestone on *Protoblastenia incrustans*, 8 VII, 1982, *Mayrhofer & Poelt*, [2] (GZU 67–82); NORTH AND WEST OF AUGSBERG MOUNTAIN COTTAGE ABOVE GRINS, NW OF LANDECK, 2300–2400 m, 9 VII 1982, *Poelt* (GZU 67–82); STUBALAIER-ALPEN, GSCHNITZTAL, TRINSER PADASTER, 2200 m, 25 VIII 1977 *Schlindler & Steiner*, Plantae Graecenses Exs. 421 (B, H); **IRAN.** LAKE URMIAH, SHIRIN BOLAGH, 37°11'07.99"N, 45°23'39"E, 1290 m, on limestone, on *Caloplaca alociza*, 9 V 2007, *Vondrák 5142* (PRM 857464), *5438* (CBFS, UCR); **USA. CALIFORNIA: Riverside Co.** SAN JACINTO MOUNTAINS, SAN BERNARDINO NATIONAL FOREST, HILLSIDE ABOVE CEDAR TRAIL, 33°39'23"N, 115°40'07"W, 1692 m, on *Caloplaca* species on limestone, 29 X 2004, *Knudsen 2012* (UCR); **NEBRASKA:** SCOTT BLUFF NATIONAL MONUMENT, along top of SW ridge, 41°50'07"N, 103°42'14"W, 243 m, 3 VII 1997, *Wetmore 77647* (MIN); **NORTH DAKOTA:** THEODORE ROOSEVELT NATIONAL PARK, SOUTH UNIT, RIDGE NW OF BUCK HILL ON ROCK LEDGES AND IN PRAIRIE, 847 m, no lichen host apparent, 26 VII 1982, *Wetmore 45159* (MIN); **TURKEY. Bitlis.** LAKE VAN, 4.5 KM SW OF ADILCEVAZ, 38°47'00"N, 42°41'00.68"E, on *Caloplaca erodens* & *C. albopruinosa* with *Opegrapha vulpina*, 12 V 2007, *Vondrák 5139* (PRM 857465).

Species excluded from the genus *Polysporina*

4. *Sarcogyne lapponica* (Ach. ex Schaer.) K. Knudsen & Kocourk., comb. nov.

MYCOBANK MB 511743

Type: **EUROPE.** on wood, H-ACH 178 (LECTOTYPE designated here).

Basionym. *Lecidea lapponica* Ach. ex Schaer., Lichen. Helvet. Spicil., p. 205 (1833).
≡ *Biatorella lapponica* (Ach. ex Schaer.) Almq., Botan. Notiser, p. 67 (1866).
≡ *Acarospora lapponica* (Ach. ex Schaer.) Th. Fr., Lich. Scand., p. 218 (1871).
≡ *Myriospora lapponica* (Ach. ex Schaer.) Hue, Morph. et Anat., p. 165 (1909).
≡ *Polysporina lapponica* (Ach. ex Schaer.) Degel., Acta Reg. Soc. Sci. Litt. Gothob., Bot. ser. 2: 103 (1983 ['1982']).

= *Acarospora tromsoeensis* Norman, Kgl. Norske Vidensk.-Selsk. Skritter, Vol. 5., p. 340 (1868). Type: **NORWAY. Troms.** TROMSØ, *Norman* (W, LECTOTYPE designated here; S, UPS, ISOLECTOTYPES).

DESCRIPTION – Non-lichenicolous, lichenized. THALLUS endolithic in rock or thin ochraceous crust in surface of wood, 20–30 µm thick, composed of thin intricate hyphae, indeterminate and discontinuous, sometimes reduced to small area around or below apothecium.

APOTHECIA black, 100–400(–500) µm diam, 150–300 µm tall, in fertile globose or subglobose stromata opening more or less to expose apothecial disc, sessile, dispersed, rarely contiguous, with no evidence of vegetative division. Disc pale-reddish to yellow-brown, flat, without carbonization of the epihymenium, 40–300 µm diam, sometimes best seen when wetted. Thalline margin lacking, margin carbonized, smooth to rough, more or less fissured, but lacking distinct joint lines as in *S. privigna*. EXCIPULUM derived from ontogeny of the wall of globose infertile stroma, up to 100 µm thick, outer layer ca. 20–50 µm thick, of indistinct carbonized hyphae, the inner layer 20–50 µm thick, containing crystals, distinct or indistinct from an innermost layer of thin prosoplectenchyma continuous with hypothecium. Indistinct medullary area beneath hypothecium mixed with substrate. Photobiont, chlorococcoid green alga, 6–16 µm diam, not forming a clear stratum in thallus or under apothecia, sometimes not evident. HYMENIUM 100–140 µm tall, hyaline, epihymenium dark, conglutinate, 20 µm thick. PARAPHYSES 1 µm diam, coherent, with some branching, apices unexpanded. ASCI clavate 50–75 × 15–22 µm, *Acarospora*-type. ASCOSPORES about 100 per asci, simple, hyaline, narrowly ellipsoid, 2.5–5 × 1–1.5 µm. SUBHYMENIUM 20–35 µm thick, hyaline, subparaplectenchyamatous. HYPOTHECIUM is 10–15 µm thick, somewhat obscure beneath subhymenium. CONIDIOMATA not observed, but probably in young infertile globose stromata.

ECOLOGY AND SUBSTRATE – In open habitat on slate or gneiss, probably rarely on wood, non-lichenicolous, sometimes occurring with *Polysporina simplex*.

DISTRIBUTION – Europe (Norway, Sweden, Switzerland).

DISCUSSION – The systematic and nomenclatural history of *Sarcogyne lapponica* has seen it placed in five genera. Schaerer (1833) originally described the species as a *Lecidea* based on concepts in his period. Almquist (1866) placed it in *Biatorella*. Fries (1871) transferred it to *Acarospora*. The description of Hue (1909) is based on the Acharius types and he transferred the species to the genus *Myriospora*, which is currently monotypic, containing only *M. heppii* (Nägeli ex Körb.) Hue (Harris & Knudsen 2006, Knudsen 2008c). Degelius (1986) transferred the name to *Polysporina* and applied it to the lichenicolous taxon discussed in this paper as *P. subfuscescens*. Examination of the type for this paper resulted in the discovery that the Acharius specimen is lichenized and lignicolous and that *P. lapponica* is actually a *Sarcogyne* species that is totally unrelated to the lichenicolous taxon we recognize in this treatment as *P. subfuscescens*.

The development of the ascocarp in *S. lapponica* occurs in two stages. In the first stage an infertile globose stroma develops, probably containing pycnidia. In the second stage, the stroma becomes fertile, more or less opening into a flat apothecium. The two-stage development is characteristic of a number of species of the core group of *Sarcogyne* (*S. clavus*, *S. privigna*, and *S. reebiae*

K. Knudsen). *Sarcogyne* s. str. differs from *Polysporina* primarily in not developing carbonization of apothecial surface. Because *Lecidea lapponica* has both the two-stage development of the ascocarp and lacks epihymenial carbonization, it is transferred to the genus *Sarcogyne.*

Magnusson's concept of *Sarcogyne lapponica* as *Acarospora lapponica* (Magnusson 1924, 1929) includes the heterogeneous *Lecanora belonioides* Nyl., which he synonymized with *A. lapponica. Lecanora belonioides* was described from a specimen from Japan and is similar to taxa of Nylander's broad concept of *Acarospora fuscata* (Schrad.) Arnold (Nylander 1864), and the combination *Acarospora belonioides* (Nyl.) Arnold was made. In the Asian specimens of *L. belonioides* we examined (H!, S!), there were at least two taxa, one a definite *Acarospora* and the other a probable *Sarcogyne.* We reject the synonymization of *L. belonioides* with *S. lapponica* (Magnusson 1924, 1929). *Lecanora belonioides* needs to be revised beginning with fresh and ample collections from Japan, the type area. Magnusson's reports of *S. lapponica* occurring in Asia are based on *L. belonioides*. The distribution of *S. lapponica* is currently recognized as being restricted to Norway, Sweden, and Switzerland.

Making ample field collections on rock is problematic because not only is *Sarcogyne lapponica* minute but it also sometimes occurs with *Polysporina simplex*. When the ascocarps of *S. lapponica* are not fully open exposing the disc it would be hard to distinguish from *P. simplex*, especially when the excipulum becomes rough and somewhat fissured. *S. lapponica* is distinguished from *P. simplex* by the lack of epihymenial carbonization and usually globose ascocarps, otherwise the internal structure of the hymenium and the size of ascospores are the same. In some of specimens we examined Magnusson misdetermined *P. simplex* as *S. lapponica.*

In the Swedish key for *Sarcogyne* (Foucard 2001) the couplet distinguishing *S. clavus* and *S. privigna* would need to be revised adding and distinguishing *S. lapponica* as having apothecia 0.1–0.4 mm, grouped with *S. privigna,* and having a hyaline hypothecium.

Another problem in identifying *Sarcogyne lapponica* is that *S. algoviae* H. Magn. has been reported from Fennoscandia (Santesson et. al. 2004). *Sarcogyne algoviae* is a member of the core group of *Sarcogyne* and is distinguished by the small size of its apothecia (0.3–0.5 µm diam) and its hyaline hypothecium. It has overlapping measurements of the paraphyses and ascospores with *S. lapponica* and *P. simplex*, but while both those species have hymenia generally above 100 µm tall, *S. algoviae* has a hymenium 50–60 µm tall. Based on the specimens of *S. algoviae* that Claude Roux supplied to us, it is distinguished from *S. lapponica* by a highly carbonized and fissured excipulum with somewhat flattened ascocarps immersed in the substrate and in being a calciphile usually occurring on dolomite. *Sarcogyne algoviae* needs further study.

Specimens examined – **SWITZERLAND.** 12 VII 1921, *Frey* (UPS); **SWEDEN. Västergötland.** floby, VIII 1915, *Vrang* [2] (UPS); **Torne Lapmark.** par. jukkasjärvi, björkliden, VII 1927, *Vrang* (S); abisko district, on slate, 2 VIII 1921, *Magnusson 6165* (S); 1924, *Malme* (S).

Conclusion

Future revisions of the lichenicolous *Polysporina* would benefit from molecular studies at the genus and family level. A robust molecular phylogeny could corroborate the species concepts defined in this paper, determine the placement of *Polysporina* within the family *Acarosporaceae* and its relationship to *Sarcogyne* s. str., and give insight into the loss of lichenization within the family *Acarosporaceae.*

In *Acarosporaceae*, narrow species concepts do not hold up well when taxonomic studies are done of a larger set of multi-regional specimens. Future description of new taxa in *Polysporina* should not be based on Magnusson's narrow species concepts.

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Nomenclatural note on an Asian *Pluteus*

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Abstract — Asian *Pluteus* taxa are not as well known as those from Europe and North America. *Pluteus australis* Z.S. Bi, one of the taxa described as new from Asia, is an illegitimate later homonym of *Pluteus australis* Murrill, a species described as new from the USA. Hence, the new name, *Pluteus bii*, is presented for the former species.

Key words — *Agaricales*, *Basidiomycota*, nomenclature, *Pluteaceae*

Introduction

Pluteus Fr., an agaric genus, is a circumglobal saprotroph and commonly lignicolous (Singer 1986). Relatively little is known about the *Pluteus* mycota of China and Korea. For such a large area with a diverse flora, few new species of *Pluteus* have been described. In fact, based on available literature, *Pluteus luteus* (Redhead & B. Liu) Redhead (Redhead 1984) and *Pluteus australis* Z.S. Bi (Bi 1988), both from China, are the only *Pluteus* taxa reported as new from this area. Lee et al. (1992) reported on the Korean *Pluteus* mycota, but they did not recognize any new taxa and none of the species they listed were described as new from Asia.

Bi (1988) was unaware when he discovered and named *Pluteus australis* Z.S. Bi, a species in *Pluteus* section *Hispidoderma* Fayod, that *Pluteus australis* Murrill, a species in *Pluteus* section *Pluteus* (Banerjee & Sundberg 1995), had already been described from the USA (Murrill 1945). According to the International Code of Botanical Nomenclature (McNeill et al. 2006), *Pluteus australis* Z.S. Bi is an illegitimate later homonym. Because of this, a replacement name is needed and, the following new name is proposed in honor of Bi Zhi-Shu.

Taxonomy

Pluteus bii Minnis & Sundb., **nom. nov.**

MycoBank 511726

≡ *Pluteus australis* Z.S. Bi, Acta Mycol. Sin. 7: 90, 1988, non *Pluteus australis* Murrill, Proc. Florida Acad. Sci. 7: 119, 1945 ("1944").

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The macrofungal checklist of Liguria (Italy): current survey status

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Abstract — The goal of this paper is to integrate and update the first edition of the checklist of Ligurian macrofungi with data resulting from mycological research conducted mainly in holm-oak woods during the past last three years. Of the 172 new taxa collected, 15 represent *Ascomycota*, 157 represent *Basidiomycota;* 12 taxa are recorded for the first time from Italy and many others are considered rare or infrequent. Each taxonomic entry includes Latin name, author, habitat, height, and WGS-84 Global Position System (GPS) coordinates. This work, together with the original Ligurian checklist, represents a contribution to the national checklist. The complete checklist is available at http://www.mycotaxon.com/resources/weblist.html.

Key words — mycological flora, new reports, species richness

Liguria represents a very interesting region from a mycological point of view. Zotti & Orsino (2001) have noted that its macrofungi, directly and indirectly associated with the vegetation, are frequent, abundant, and highly diverse. Observations support a high level of fungal biodiversity (sometimes called "mycodiversity") for Liguria, which covers only about 2% of the Italian territory but with 36% of all species recorded in Italy represented. Moreover, species richness is likely underestimated, as only 50% of Liguria was actually investigated (see Fig. 1 in the web Checklist). It is significant that such a brief study carried out in such a limited number of new areas increases so greatly the total number of species observed. The new data used to update the previous Ligurian checklist (Zotti & Orsino 2001) and Italian checklist (Onofri et al. 2005) are based primarily on collections made in previously unsurveyed holm-oak woods (*Quercus ilex* L.). Statistical analyses of some sites by Zotti (2004) confirm the high level of mycodiversity of the region. The paper reports data of mycological investigations carried out through the last six years (2001–07). Moreover, a brief annex is also included that lists the species recorded in Liguria and described in recent papers.

Methodology—Each collection was identified based on macro- and micromorphological characters. References consulted included Alessio & Rebaudengo (1980), Antonini & Antonini (2002), Bas et al. (1988, 1990, 1995, 1999), Basso (1999), Bernicchia (2005), Bon (1984), Breitenbach & Kränzlin (1984), Consiglio (1996), Consiglio et al. (2003, 2004, 2005), Contu (2000, 2003), Eyssartier & Buyck (2000), Fontenla et al. (2003), Fraiture (1993), Frøslev et al. (2006), Grupo Ibero-insular de Cortinariologos (GIC 2007), Jülich (1989), Kreisel (1987), Ladurner & Simonini (2003), Malençon & Bertault (1970), Moser (1980), Noordeloos et al., (2001), Raillère & Gannaz (1999), Riva (1988, 2003), Robich (1990), Romagnesi (1967), Sarnari (1998, 2005), Stangl (1991), Traverso (1999), Vesterholt (2002). A Garmin (eTrex Summit) Global Position System (GPS) was used to determine collection sites in WGS-84 coordinates in decimal degrees. Family, order and class names follow Kirk et al. (2001), Vizzini (2004), and Hibbett (2006). Abbreviation of author names follows Brummitt & Powell (1992) and IPNI (2008). Several species cited in the previous checklist have since been documented by Balletto (1972). The new records are intended to add previously omitted collection and site information (indicated with an asterisk in the taxonomic list). Species flagged with "☒" represent taxa not yet cited in Italian checklist (Onofri et al. 2005). Finally, the annex reports a group of species recently observed and the related bibliographic references.

Results—172 taxa, representing 58 genera and 35 families, were recorded. The list is arranged alphabetically in order to simplify the seeking and the reading of species. Each taxonomic entry provides the Latin name, authority, WGS-84 Global Position System (GPS) coordinates in decimal degrees, altitude, survey date when the species was first found, and collection site habitat.

Conclusions—The weblist lists new species observed in Liguria (primarily from holm-oak habitats) during the 2001–07 mycological surveys. The newly recorded 172 taxa represent *Basidiomycota* and *Ascomycota*. The paper emphasizes the preliminary nature of mycological research in Liguria and draws attention to its unusually high level of fungal richness. Although the areas where the species were collected represent a negligible portion of the whole Ligurian territory, the increase of observed species comprises approximately 13% of all the records of the previous list. Furthermore, 12 basidiomycetes — *Cortinarius chevassutii* Rob. Henry, *C. ionochlorus* var. *leucophyllus* Malençon, *C. murellensis* Cors. Gutiérrez et al., *C. parasuaveolens* (Bon & Trescol) Bidaud et al., *C. sancti-felicis* Frøslev & T.S. Jeppesen, *C. veraprilis* Chevassut et al., *Inocybe squarrosa* Rea, *Laccaria macrocystidiata* (Migl. & Lavorato) Pázmány, *Melanoleuca amica* (Fr.) Singer, *M. grammopodia* var. *obscura* Bon, *Russula subazurea* Bon, *Xerula radicata* var. *alba* Dörfelt — have not been previously cited in the Italian checklist (Onofri et al. 2005). These facts should encourage studying new territories and habitats. Finally, taxonomic reevaluations of complex genera such as *Russula* and *Cortinarius* might uncover species not previously recognized in the country.

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Gloeoporus dichrous var. *niger* comb. nov.

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Abstract — Molecular phylogenetic study of *Ceriporiopsis nigra*, a species known only from its type locality, was performed to reveal its evolutionary relationship to *Ceriporiopsis pannocincta* and to the type species of the genus, *C. gilvescens*. The sequencing of ITS and mitochondrial SSU regions of ribosomal DNA revealed identity of the sequences of *C. nigra* and *Gloeoporus dichrous*, apart from *Ceriporiopsis*. Even though *C. nigra* and *G. dichrous* share similar microscopy, the two species differ remarkably in colour of basidiocarp. Thus, the new combination *Gloeoporus dichrous* var. *niger* is proposed.

Key words — *Basidiomycota*, taxonomy, polyporoid clade

Introduction

Although the European mycobiota is relatively well investigated, every now and then new species are still described at the beginning of the 21th century. An example of such a species is *Ceriporiopsis nigra* (Ryvarden 2003), to date known only from the type locality. The species was placed in *Ceriporiopsis* due to its resupinate, poroid hymenophore with monomitic hyphal system and clamps. *C. nigra* seems to be related to *Ceriporiopsis pannocincta (Gloeoporus pannocinctus)*. Both species share a distinct resinous layer between the tubes and context and similar shape of basidiospores, but they differ in pore width. Due to a probable polyphyletic origin of *Ceriporiopsis* as currently conceived (Ryvarden & Gilbertson 1993), we decided to test the taxonomic position of the included species by molecular methods comparing *C. nigra* not only with *C. pannocincta* but also with the generic type species *C. gilvescens*.

Material and methods

To assure the taxonomic position of *Ceriporiopsis nigra* sequencing of the ITS region of nuclear ribosomal DNA (ITS) and small subunit of mitochondrial ribosomal DNA (mitSSU) were carried out.

The holotype of *C. nigra* (deposited in O herbarium; Ryvarden no. 17528) was sequenced together with collections of *Ceriporiopsis gilvescens* and *C. pannocincta* (collected in the Czech Republic, deposited in BRNM herbarium; specimens no. 709970 and 709972, respectively).

DNA was isolated from the dried tissue of herbarium specimens using PowerSoil™ DNA Isolation Kit (Mo-Bio). For amplification of ITS and mitSSU the primer pairs ITS1/ITS4 and MS1/MS2 were used (White et al. 1990). The DNA was amplified with PCR, using the Mastercycler® ep thermocycler (Eppendorf). The PCR amplifications were performed according to Tomšovský et al. (2006). The only modification was lower temperature of mitSSU region amplification (50 °C) instead of 55 °C used for ITS one. The PCR products were purified by NucleoSpin Extract II (Macherey-Nagel) prior to sequencing.

Sequences were determined with an ABI PRISM 3100 Avant DNA sequencer (Applied Biosystems) at the Department of Animal Morphology, Physiology and Genetics, Faculty of Agriculture, Mendel University, Brno using the ABI PRISM BigDye terminator v1.1 cycle sequencing kit (Applied Biosystems). All samples were sequenced with the primers used in the PCR.

GenBank search of newly obtained mitSSU sequence of *C. nigra* using BLAST (Altschul et al. 1990) resulted in 100% identity with those of *Gloeoporus dichrous* (GenBank Access. No. AY986495). Due to this result, the collection of *G. dichrous* (collected in Slovakia, deposited in BRNM herbarium; specimen no. 709971) was also sequenced to assure the phylogenetic proximity of the two species. The sequences were deposited in the EMBL Nucleotide Sequence Database, their GenBank ITS and mitSSU accession numbers are as follows: *Ceriporiopsis nigra* (EU546098, EU546101), *C. gilvescens* (EU546104, EU546103), *C. pannocincta* (EU546099, EU546102), *Gloeoporus dichrous* (EU546097, EU546100).

All sequences were edited manually using BioEdit version 4.7.1. (Hall 1999) and two sequences from the GenBank (*Gloeoporus dichrous* mitSSU sequence, AY986495; *Ceriporiopsis pannocincta* ITS one, AY219361) were added to the dataset. The combined ITS and mitSSU alignment with introduced gaps consisted of 1088 characters including 830 constant, 258 variable and 68 parsimony informative sites. The length of mitSSU sequence of *C. gilvescens* differs apparently from the other studied *Ceriporiopsis* species (1525 bp instead of 452-455 bp) due to presence of two introns, and so these heterologous regions were excluded from the study prior to aligning.

Bayesian analysis was performed using software MrBayes 3.0 (Huelsenbeck & Ronquist 2001) while the maximum parsimony analysis (MP) was performed with PAUP 4.0 (Swofford 1999). The support for the topology of MP trees was estimated using 1000 bootstrap-replicates. In MrBayes, 2×10^6 generations of the Markov Chain Monte Carlo were run with four simultaneous chains, heating temperature 0.2. First 2000 trees were discarded as burn-in.

Results and discussion

The newly obtained *Ceriporiopsis nigra* sequences of both gene regions show 100% identity to those of *Gloeoporus dichrous*. The phylogenetic analysis of combined dataset resulted in the same phylogram topologies with respect to

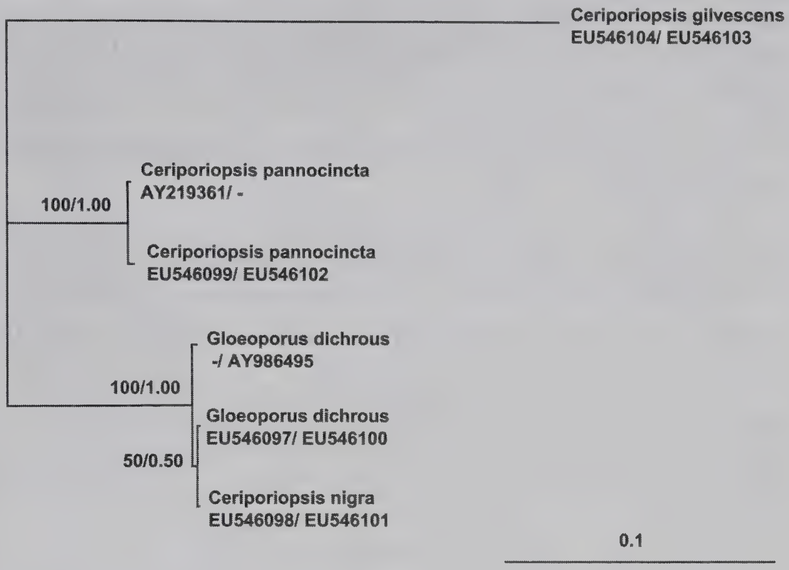
Ceriporiopsis gilvescens
EU546104/ EU546103
Ceriporiopsis pannocincta
AY219361/ -
100/1.00
Ceriporiopsis pannocincta
EU546099/ EU546102
Gloeoporus dichrous
-/ AY986495
100/1.00
Gloeoporus dichrous
EU546097/ EU546100
50/0.50
Ceriporiopsis nigra
EU546098/ EU546101
0.1

Figure 1. Phylogenetic tree of *Ceriporiopsis nigra* and related taxa based on combined sequences of the ITS and mitSSU regions of nuclear ribosomal DNA region. The unrooted tree was constructed by the Bayesian analysis. Bootstrap values from Maximum Parsimony and Bayesian posterior probabilities, respectively, are shown at the nodes. The bar indicates number of substitutions per position.

the used MP and Bayesian analyses (Fig. 1). The MP analysis gave 278 most parsimonious trees; tree length = 278, consistency index (CI) = 1.000, and retention index (RI) = 1.000.

Analyses revealed that *C. nigra* is more closely related to *Gloeoporus dichrous* than to the type species of *Ceriporiopsis*. *Ceriporiopsis pannocincta* is also more proximal to the *C. nigra* / *Gloeoporus dichrous* clade than to *C. gilvescens*. Accordingly a new combination is proposed:

Gloeoporus dichrous **var.** ***niger*** (Ryvarden) Tomšovský & Ryvarden, **comb. nov.**
MycoBank : MB 511831
Basionym: *Ceriporiopsis nigra* Ryvarden, Windahlia 24: 26, 2001, as '*niger*'.

Basidiocarps annual, resupinate, brittle when dry, 1–2 mm thick, margin narrow and white, pore surface first ochraceous becoming blackish brown, pores thin-walled, angular, 2–3(–4) per mm, tube layer concolorous, resinous and brittle up to 1 mm deep, black resinous zone present above the tubes, about 0.1 mm thick, subiculum white, up to 0.5 mm thick.

Hyphal system monomitic, generative hyphae hyaline, thin to slightly thick-walled, with clamps and branched, negative in Melzer's reagent, 2–6 µm in diam. Cystidia and other sterile hymenial elements absent. Basidia clavate, four-sterigmate, 12–14 × 3.5–4.5 µm, with a basal clamp. Basidiospores allantoid, hyaline, smooth, negative in Melzer's reagent, 3.7–4.0 × 0.8–1.0 µm. Causing white rot of dead lying trunk of *Populus tremula*. Known only from the type locality in Østfold county, Norway.

Gloeoporus dichrous var. *niger* and *G. dichrous* have identical morphological and molecular characters, e.g. basidiocarp morphology, hyphal system and basidiospore dimensions (Ryvarden & Gilbertson 1993, Ryvarden 2001). On the other hand, *Gloeoporus niger* lacks the apparent reddish to purplish tint of pore surface so typical for *G. dichrous* but this character is not sufficient to discriminate the fungi at the specific level. The occurrence of intermediate forms between the new described variety and *G. dichrous* s.s. has not yet been verified. If populations concerning both taxa would be discovered, the interfertility between them should be tested to reveal a possible intersterility.

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Notes on *Heteroconium* and a new species from Venezuela

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Abstract — *Heteroconium avilae* sp. nov., found on the decaying rachis of an unidentified palm tree in "Cerro El Ávila" near Caracas, Venezuela, is described and illustrated. *Heteroconium avilae* is characterized by cylindrical to fusiform, sometimes slightly navicular, 1- to 3- or rarely 4-septate, smooth conidia that have dark brown to brown central cells and pale brown end cells. Illustrations of conidia of published *Heteroconium* species are provided. A key to *Heteroconium* species is presented.

Key words — anamorphic fungi, systematics, tropical rainforest

Introduction

During three expeditions in 2006 through Venezuela's "Cerro El Ávila" rainforest, 102 anamorphic fungi were examined from plant material on soil or submerged in water, and a conspicuous fungus from the genus *Heteroconium* was collected. The specimens showed differences from previously described species and are therefore described as a new species.

Materials and methods

Samples of plant litter collected in separate paper bags were taken to the laboratory where each was incubated at 25° C in Petri dishes within 50 L plastic moist chambers containing 200 ml sterile water and 2 ml glycerol. The plant material was screened at regular intervals for microfungi. Mounts were prepared in polyvinyl alcohol-glycerol (8 g per 100 ml H_20, plus 5 ml glycerol), and measurements were made at a magnification of × 1000.

Taxonomy

Heteroconium avilae R.F. Castañeda, Iturr., Heredia & Minter **anam. sp. nov.**

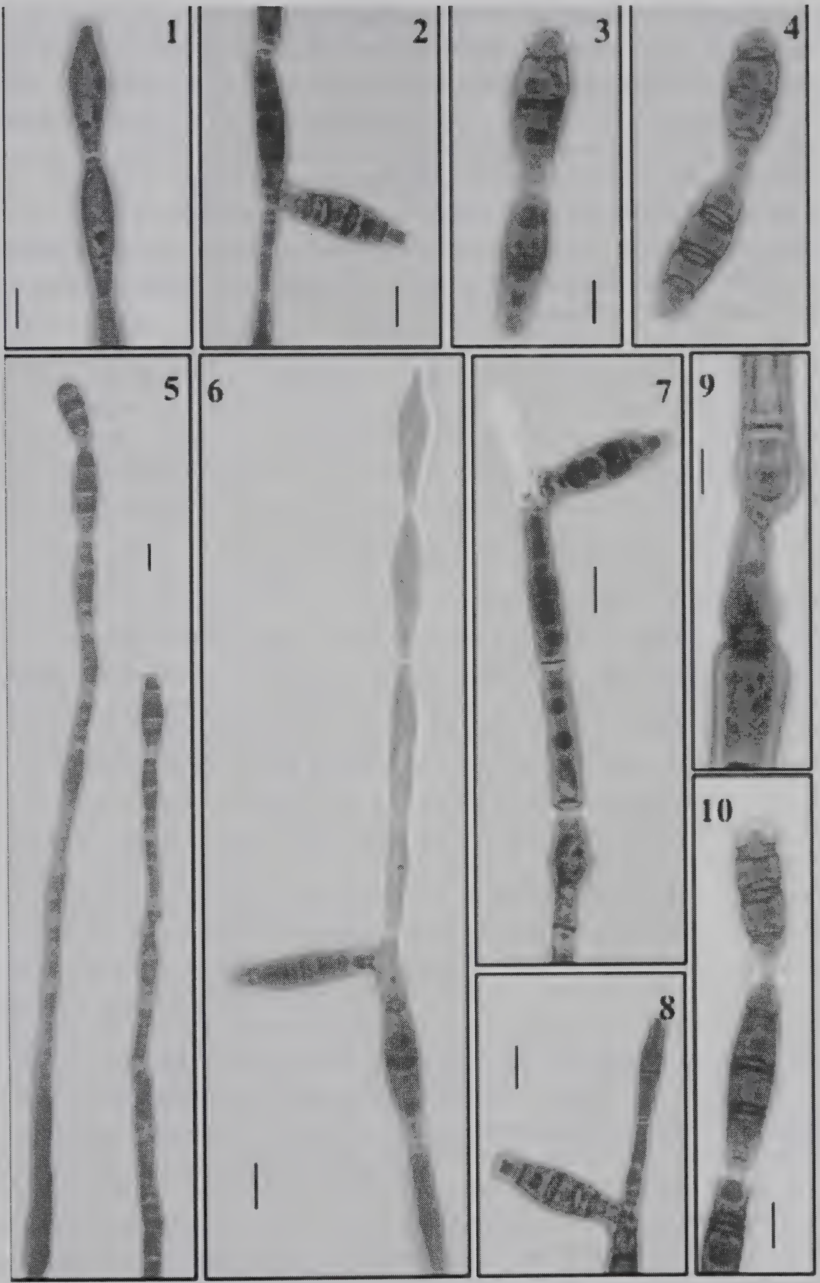
MycoBank MB 511192 **Figs. 1-10**

Coloniae in substrato naturali effusae, nigrae. Mycelium partim superficiale et partim in substrato immersum, ex hyphis septatis, laevibus, atrobrunneis vel brunneis, 1-2 µm diam., compositum. Conidiophora macronematosa, mononemata, erecta, recta, cylindrica, 6- usque ad 14-septata, laevia, 180–375 × 16–25 µm, nigra vel atrobrunnea ad basim et pallide brunnea ad apicem. Cellulae conidiogenae hologenosae, uniloculosae, laeves, dilute brunneae, 18–25 × 6–8 µm, in conidiophoris incorporatae, interdum cum 1-2 proliferationibus percurrentibus cylindricis praeditae. Secedentia conidiorum schizolytica. Conidia cylindrica usque fusiformia, interdum leviter navicularia, 1- ad 3- (raríssime 4-) septata, utrimque truncata 23–33 × 8–12 µm, cellulis cum centralibus brunneis et utrimque dilute brunnea, laevia, sicca, blastocatenulata cum catenis fasciaria formata. Teleomorphosis: ignota.

TYPUS: Venezuela, Caracas, "Cerro El Ávila", on decaying rachis of an unidentified palm tree. Coll. A. Fernández, 17.VI.2006. Holotype: INIFAT C06/47-1. Isotype: USB C06/47-1.

Etymology: Latin, *avilae*, in reference to "El Ávila" mountain from Caracas, Venezuela.

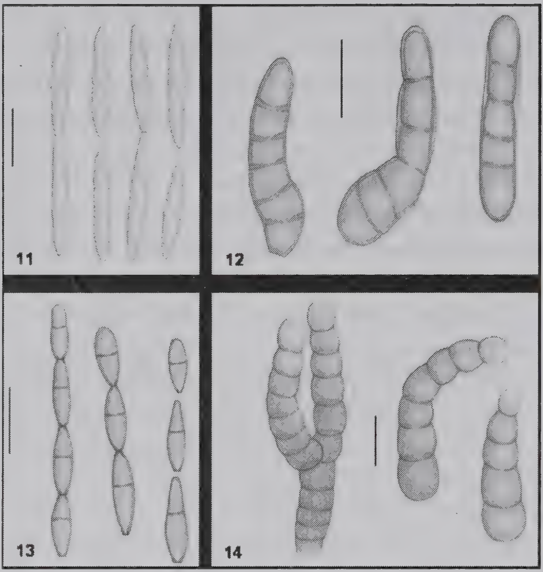
Colonies on the natural substratum effuse, black. Mycelium superficial and immersed, composed of septate, smooth-walled, dark brown or brown hyphae, 1–2 µm diam. Conidiophores macronematous, mononematous,



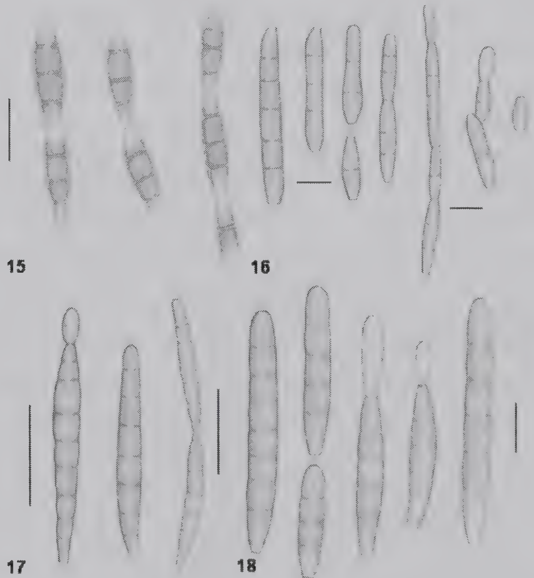
Figs. 1-10 *Heteroconium avilae*, from holotype (INIFAT C06/47-1). **Figs. 1-4, 10**. Conidia. **Figs. 5-9.** Conidiogenous cells and conidial chains. Scale is indicated by bars = 10 µm.

erect, straight, unbranched or with a secondary branch near the proliferation, cylindrical, 6- to 14-septate, smooth-walled, 180–375 × 16–25 µm, black to dark brown at the base and pale brown towards the apex. CONIDIOGENOUS CELLS hologenous, unilocal, smooth-walled, pale brown, 18–25 × 6–8 µm, integrated, with 1-2 cylindrical percurrent proliferations. CONIDIAL SECESSION schizolytic. CONIDIA cylindrical to fusiform, sometimes slightly navicular, truncate at the base and apex, but the distal conidium rounded at the apex, 1- to 3-septate, rarely 4-septate, 23–33 × 8–12 µm, the central cells brown to dark brown, the end cells very pale brown, guttulate, smooth-walled, dry, blastocatenulate with band-shaped pigmentation. TELEOMORPH: unknown.

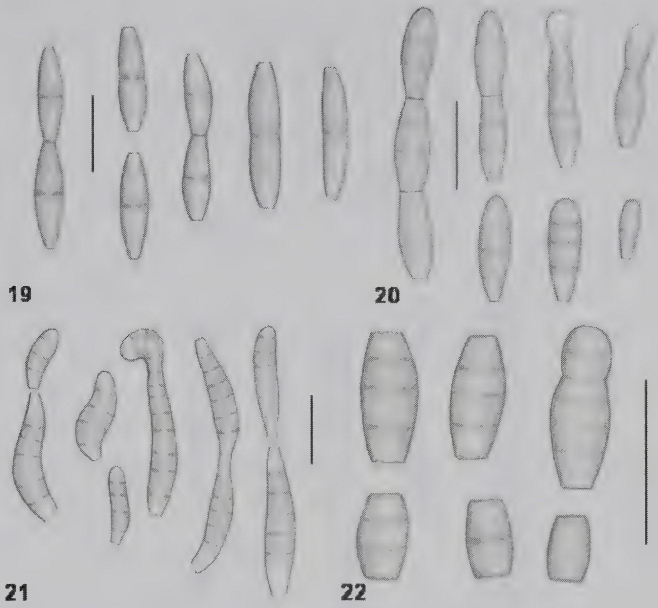
COMMENTS: The genus *Heteroconium* was erected by Petrak (1949) for the type species, *H. citharexyli* Petr., and is distinguished by macronematous, mononematous conidiophores usually unbranched or with a few branches originating after conidial secession or near percurrent proliferations (Castañeda et al. 1999, Taylor et al. 2001). *Heteroconium avilae* slightly resembles *H. asiaticum* R. Chaudhary et al., but that species has pale brown, 2- to 3-septate, 40–80 × 3.5–5.5 µm conidiophores and conidia that are cylindrical, tapered at the ends, pale brown, 0- to 4-septate, and 13–24 × 5–6.5 µm. Hughes (2007) comments that *H. asiaticum* has probable affinities with the sooty moulds because it was described as having superficial mycelium on living leaves. After Morgan-Jones (1976) and Castañeda et al. (1999) outlined the characters and details of *Heteroconium* species, several other species were described: *H. neriifoliae* Joanne E. Taylor et al., *H. eucalypti* Crous & M.J. Wingf., *H. glutinosum* (Cooke & Harkn.) S. Hughes & J.L. Crane and *H. kleinziense* Crous & Z.A. Pretorius, *H. triticicola* Kwaśna & G.L. Bateman and *Heteroconium* anam. (Hughes of *Antennulariella concinna* (L.R. Fraser) S. Hughes. *Helminthosporium solaninum* Sacc. & P. Syd. (as '*Helmisporium*') the basionym of *Heteroconium solaninum* (Sacc. & P. Syd.) M.B. Ellis was recently designated as type species of the genus *Pirozynskiella* S. Hughes based on "their obligate association with asterinaceous fungi, by general rather than apical (acropetal) extension of conidium initials and by the centrifugal (then interseptal) sequence of septation of conidia following the first median septum" (Hughes 2007). *Heteroconium chaetospira* (Grove) M.B. Ellis was transferred to *Cladophialophora* as *C. chaetospira* (Grove) Crous & Arzanlou after a molecular study of the *Herpotrichiellaceae* and *Venturiaceae*. *Heteroconium tetracoilum* (Corda) M.B. Ellis has distoseptate conidia and was transferred to *Lylea* as *L. tetracoila* (Corda) Hol.- Jech. (as '*tetracoilum*'); however Hughes (2007) indicated that *Lylea* is not an appropriate home for this taxon, pointing out that *Heteroconium tetracoilum* and *H. chaetospira* are both fungicolous species. The genus *Heteroconium* as currently circumscribed probably remains polyphyletic; Hughes (2007) described the sequence of conidium septation in *H. citharexyli* as "basifugal" (i.e. the first formed septum is at the base of the conidium, with subsequent septa produced in sequence from base to apex) and indicated that this consistent character should be recognized and documented in the description of anamorphs. The genera *Lylea* Morgan-Jones, *Xenoheteroconium* Bhat et al., *Cladophialophora* Borelli, *Septonema* Corda, *Phaeoblastophora* Partr. & Morgan-Jones, and *Taeniolella* S. Hughes are morphologically close to *Heteroconium.* However, *Lylea* produces distoseptate conidia in unbranched chains on monoblastic, determinate, integrated conidiogenous cells, while *Xenoheteroconium* forms euseptate conidia in branched chains and two kinds of propagules that originate from monoblastic, terminal conidiogenous cells, although sympodial proliferations occur in fertile areas found within the conidial chains. *Cladophialophora* is distinguished by micronematous or undifferentiated conidiophores (usually reduced to conidiogenous cells) with phialidic synanamorphs often present; pale pigmented, 0- to 1-septate, rarely (3-septate) conidia with inconspicuous scars are produced in branched chains in the genus. *Septonema* is characterized by monoblastic or polyblastic, integrated or discrete conidiogenous cells and (0-)1- to 3-septate conidia tapering to truncate ends that are produced in branched chains. *Phaeoblastophora* is distinguished by mono- or mostly polyblastic, integrated, terminal or intercalary conidiogenous cells and acropleurogenous, unicellular conidia produced in simple or branched chains. *Taeniolella* produces semi-macronematous conidiophores that are usually short, unbranched or sparingly branched near the base and conidia that are 2- or more septate, dark pigmented, cylindrical, and produced in acropetal, simple or branched chains that often secede with difficulty. *Heteroconium nigroseptatum* V.G. Rao, nom. nud., was never validly published (MycoBank 2008). *Heteroconium queenslandicum* Matsush. appears distant from the generic concept of *Heteroconium* and more closely related to the genus *Parapleurotheciopsis* P.M. Kirk. The species exhibits a holoblastic conidium ontogeny and produces an acropetal branched chain through an apical ramoconidium that secedes schizolytically, as also found in *Parapleurotheciopsis inaequiseptata* (Matsush.) P.M. Kirk (the type species of *Parapleurotheciopsis*). As *Diploospora indica* S.K. Nair & Bhat exhibits a similar conidial ontogeny, both species could be transferred to the genus *Parapleurotheciopsis,* although we propose no new combinations here.



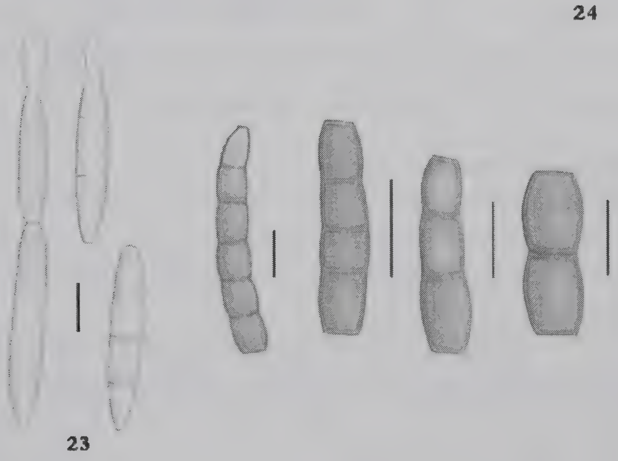
Figs.11–14. Conidia of *Heteroconium* species, redrawn from the original descriptions.
Fig. 11. *Heteroconium tropicale.* **Fig. 12.** *H. kleinziense.* **Fig. 13.** *H. ponapense.* **Fig. 14.** *H. eucalypti.*
Scale is indicated by bars: **Figs.** 11-13= 20 µm; **Fig. 14** = 10 µm.



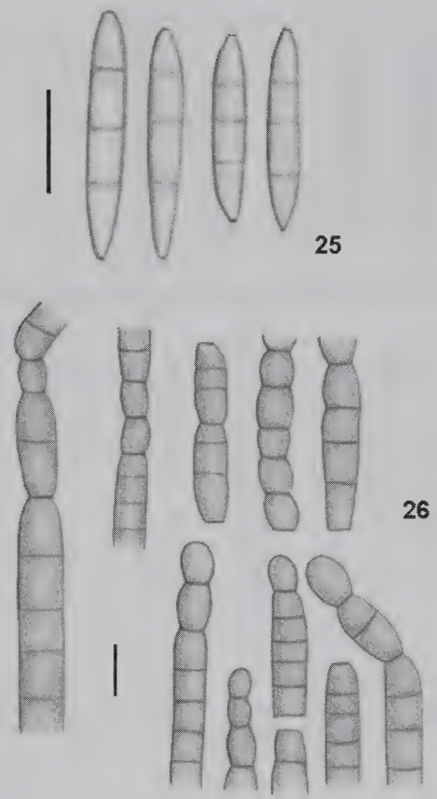
Figs.15. Conidia of *Heteroconium avilae*, from holotype (INIFAT C06/47-1).
Figs.16-18. Conidia of *Heteroconium* species, redrawn from the original descriptions.
Fig. 16. *H. glutinosum.* **Fig. 17.** *H. arundicum.* **Fig. 18.** *H. citharexyli.*
Scale is indicated by bars: **Figs. 15-16, 18** = 10 µm; **Fig. 17** = 40 µm.



Figs. 19-22. Conidia of *Heteroconium* species, redrawn from the original descriptions.
Fig. 19. *Heteroconium indicum*. **Fig. 20.** *H. lignicola*. **Fig. 21.** *H. decorosum*. **Fig. 22.** *H. asiaticum*.
Scale is indicated by bars: **Figs. 19-20, 22**= 20 μm; **Fig. 21** = 10 μm.



Figs. 23-24. Conidia of *Heteroconium* species redrawn from the original descriptions.
Fig. 23. *H. solaninum*. **Fig. 24.** *H. neriifoliae*.
Scale is indicated by bars: **Fig. 23** = 10 μm; **Fig. 24** = 5 μm.



Figs. 25-26. Conidia of *Heteroconium* species, redrawn from the original descriptions. **Fig. 25.** *H. triticicola.* **Fig. 26.** *H.* anam. *Antenulariella concinna.* Scale is indicated by bars = 10 µm.

Key to accepted *Heteroconium* species

1 Conidia with one septum 2
Conidia frequently with more than one septum 3

2 (1) Conidia fusiform to cylindrical, pale brown to reddish brown, smooth, 23–42.5 × 8.5–10.5 µm . . . . *H. indicum*
Conidia obclavate to ellipsoid, brown, smooth, 12–24 × 4–6 µm *H. ponapense**

3 (1) Euseptate and distoseptate conidia both present, conidia aseptate to multi-septate, subcylindrical to ellipsoid, verruculose, brown, 10–60 × 7–8 µm . . . . *H. kleinziense*
Only euseptate conidia present 4

4 (3) Conidia with not more than 4 euseptate septa 5
Conidia with more than 4 euseptate septa 8

* Diagnosed from pure cultures.

5 (4) Conidia 2- to 3-septate, cylindrical to fusiform, slightly tapered at the ends, pale olivaceous brown to pale brown, smooth, 16–24 × 4–4.5 µm .... ***H. solaninum***
Conidia more than 4.5 µm wide 6

6 (5) Conidia 1- to 4-septate, cylindrical, uniformly brown, smooth, 13.5–32.5 × 5.4–8.5 µm .... ***H. lignicola***
Conidia or at least their chains not uniformly pigmented 7

7 (6) Conidia with middle cells darker than end cells, 0- to 4-septate, cylindrical, tapered at the ends, pale brown, smooth, 13–24 × 5.0–6.5 µm ..... ***H. asiaticum***
Conidia 23–33 × 8–12 µm, 1- to 3- septate, rarely 4-septate, cylindrical to fusiform, slightly navicular, brown to dark brown, end cells very pale brown, guttulate, smooth, with band-shaped pigmented chains .... ***H. avilae***

8 (4) No conidia with more than 7 septa 9
Some conidia with more than 7 septa 12

9 (8) Conidia verruculose, 10–35 × 5–7 µm, 0- to 6-septate, subcylindrical to ellipsoid, brown at the base, pale brown toward the apex .... ***H. eucalypti***
Conidia smooth, 10–50 × 1.5–2.5(–3) µm, 1- to 6-septate, narrowly ellipsoid to cylindrical,with oval, thick-walled scar at both ends, subhyaline to pale brown .... ***H. triticicola****
Conidia smooth or, if not smooth, then not more than 5 µm wide 10

10 (9)Conidia 20–30 × 3–5 µm, rarely verrucose, 3- to 6-septate, navicular, broad fusiform to obclavate, sometimes sigmoid or curved, smooth .... ***H. decorosum***
Conidia mostly longer than 30 µm and / or wider than 5 µm 11

11 (10) Conidia 3- to 6-septate, slightly constricted at the septa, cylindrical to fusiform, tapered at the ends, pale brown, smooth, 26–52 × 4–6 µm .... ***H. tropicale***
Conidia ellipsoid and constricted at the septa, smooth, brown to dark brown, 9–75 × 5–9 µm, synanamorph sometimes present, globose, aseptate, at first smooth and hyaline, later verrucose and pale brown to dark brown, 11 µm diam., produced in sparingly branched chains .... ***H. glutinosum***
Conidia dimorphic, slightly constricted at the septa, shorter conidia subglobose to ellipsoid with few or no septa, longer conidia cylindrical, multiseptate, brown to dark brown, 7.2–60 × 5.4–8.6 µm .... ***H.* anam. of *Antennulariella concinna***

12 (8)Conidia verrucose with longitudinal striations or with creases, 1- to 14-septate, subcylindrical tapered at the ends, brown, (6–)18–25(–45) × (3.5–)4.5–4.5(–6) µm .... ***H. neriifoliae***
Conidia smooth 13

13 (12) Conidia 1- to 10-septate, cylindrical to fusiform, mid to dark brown, 35–95 × 8–12 µm .... ***H. arundicum***
Conidia 1- to 10-septate, slightly constricted at the septa, cylindrical to oblong, pale brown to brown, 10–40 × 3–7 µm .... ***H. citharexyli***

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The *Entolomataceae* of the Pakaraima Mountains of Guyana 2: *Inocephalus dragonosporus* comb. nov.

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Abstract — *Entoloma dragonosporum*, a saprotrophic agaric, is reported for the first time from the Pakaraima Mountains of Guyana, occurring on soil in tropical rainforests. Based on its stellate spores, clamp connections, mycenoid habit, appressed fibrillose pileus, and pileipellis morphology, this Singerian species is transferred from *Entoloma* to *Inocephalus*. The species is fully described and illustrated and the new combination *Inocephalus dragonosporus* is proposed.

Keywords—*Agaricomycotina*, *Basidiomycota*, *Dicymbe*, Guayana Highlands, Neotropics

Introduction

Entoloma dragonosporum was first described (as *Rhodophyllus dragonosporus*) on soil from the Bolivian Amazon (Singer 1965). Subsequently, it has been reported from tropical forests in central Brazil (De Meijer 2001), on rotten wood and on soil in northern Brazil (Horak 1982, Singer & Aguiar 1986), and on rotten wood in northeastern Brazil (Wartchow 2006). Additional collections have been made in Trinidad (Baroni, unpublished), Belize (Baroni, unpublished), and in Puerto Rico (Baroni 2007). Herein, this species is reported for the first time from the Pakaraima Mountains of Guyana. It has yet to be collected or reported from North America.

Species of *Inocephalus* are recognized by their mycenoid to collybioid basidiomata with appressed fibrillose or at least not truly glabrous pilei that are often acutely umbonate. Microscopically *Inocephalus* can be differentiated from other *Entolomataceae* by its basidiospores that are often, but not always, 4-sided or stellate, hyphae of the subpellis that are indistinct from the hyphae of the pileal trama, and abundant formation of clamp connections at least on the hyphae of the pileipellis. In addition the hyphal cells of the pileal and lamellar trama are extremely long. The genus *Nolanea* can easily be confused with *Inocephalus* because of its mycenoid to collybioid stature and acutely umbonate pileus. However, *Nolanea* is differentiated by its glabrous pileus, inflated hyphae of the subpellis that are distinct from the hyphae of the pileal trama, lack of clamp connections, lack of 4-sided spores, and in most species the lack of stellate spores. Basidiomata of taxa classified into *Entoloma* s. str. are fleshier, typically tricholomatoid in stature, possess abundant clamp connections, lack 4-sided or stellate basidiospores, and possess relatively short and broad hyphae in the pileal and lamellar trama. Largent (1994) provided a more detailed discussion of the genus *Inocephalus*.

Because of its mycenoid stature, papillate umbo, large stellate spores, abundant clamp connections, long hyphal cells in the pileal and lamellar trama, and the hyphae of the subpellis that are not differentiated from the hyphae of the pileus trama, *Entoloma dragonosporum* is a good example of an *Inocephalus* species, and the new combination *Inocephalus dragonosporus* is here proposed.

Materials and methods

Collections were made during the mid-May to mid-June rainy seasons of 2000–04 from the Upper Potaro River Basin, within a 5 km radius of a permanent base camp at 5° 18′ 04.8′′ N; 59° 54′ 40.4′′ W; elevation 710m. Collections were made in both mixed tropical forest, and in forests dominated by the leguminous, ectomycorrhizal (EM) tree *Dicymbe corymbosa* Spruce ex Benth. Macroscopic features were described fresh in the field. Colors were described subjectively and coded according to Kornerup & Wanscher (1978), with color plates noted in parentheses. Abbreviations used in specific descriptions indicate page number, the column, and the row; for example 8D–F5–6 indicates page 8, columns D to F, and from rows 5 to 6. Herbarium designations are according to Holmgren et al. (1990).

Micromorphological features of dried specimens were examined with a trinocular research-grade Nikon Labophot compound microscope fitted with light contrast optics. General techniques used follow Largent (1994); techniques used for measuring spores of *Entolomataceae* followed Baroni (1998). Digitized photomicrographs were made using a Nikon Coolpix 990 focused through the trinocular head of the compound microscope.

All microscopic measurements were obtained using a GTCO Corporation Graphic Digitizer, Model DP5A–111A connected to an IBM compatible Chem Book Laptop computer. The software utilized was Measure Me 101 v 1.0 which is modified for use on a contemporary laptop computer from a BASIC program called Metrics5 developed and provided by David Malloch, University of Toronto. The mathematical results from this program are summarized in Largent (1994). Factors determined include: $\overline{x}$, the arithmetic means of spore length and spores width ± standard deviation; E, the quotient of spore length by spore width indicated as a range variation in n objects measured; Q,

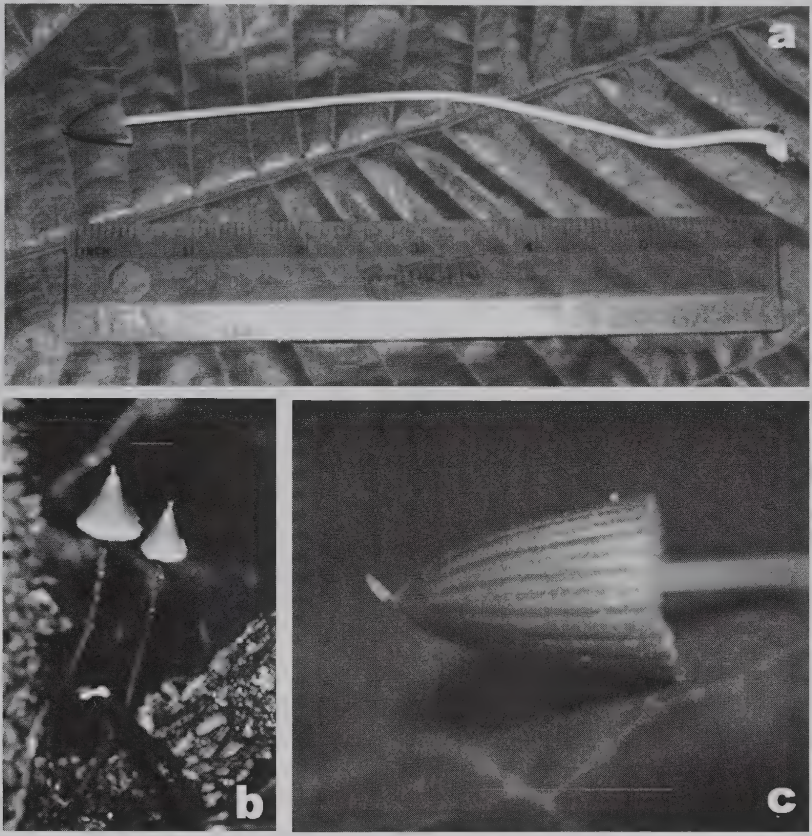

Figure 1: *Inocephalus dragonosporus* basidiomata.
a. MCA 1563; b. field aspect (MCA 968); c. papilla (MCA 1563).

the mean of E-values ± standard deviations, and for spores only, L-D the length-diameter of spores, and AL-D the average L-D ± standard deviation for n spores measured; n/4 indicates the number of objects measured/in the number of collections studied.

Taxonomy

Inocephalus dragonosporus (Singer) T.J. Baroni & Largent **comb. nov.** FIGS 1-2
MYCOBANK MB511283

≡ *Rhodophyllus dragonosporus* Singer, Atas Inst. Micol. 2: 46. 1965.

≡ *Entoloma dragonosporum* (Singer) E. Horak, Sydowia 29: 292. 1977.

PILEUS 6–27 mm tall, 7–25 mm broad at base, conic, rounded at apex and terminated by an acute nipple-like papillus which is ephemeral with age, off-white to hyaline at first, glabrous, 1.5–2 mm × 1 mm; surface moist, brown (6E4–

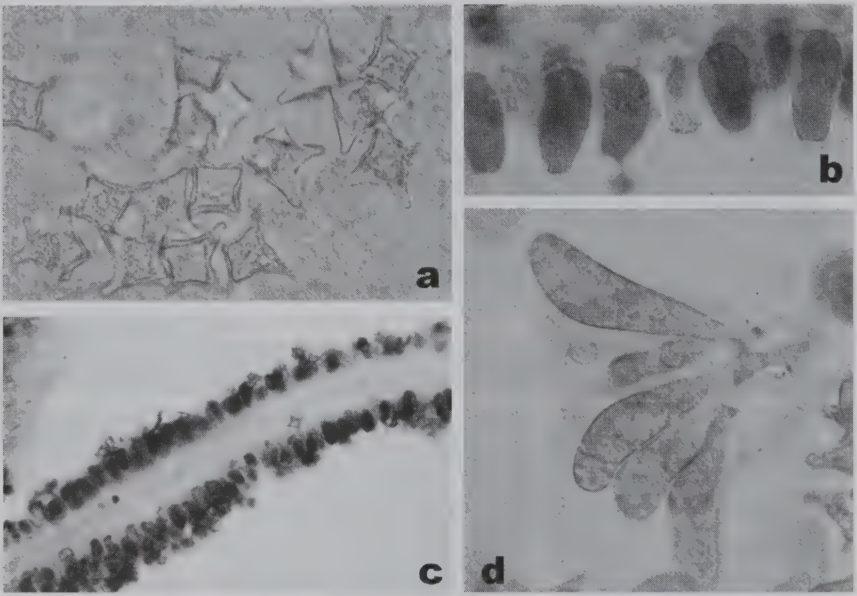

Figure 2: *Inocephalus dragonosporus* micromorphological characters. a. basidiospores (MCA 1563); b. basidia (MCA 1230); c. cyanophilic basidia (TH 8663); d. cheilocystida (TH 8663).

5) to dark brown (5E6) throughout with darker brown translucent striations, densely radially appressed-fibrillose, fibrils longitudinally striate over entire length; pileus margin crenate to shallowly scalloped. LAMELLAE adnate to subadnexed, oriented long and almost parallel, narrow to moderately broad, 0.5–4.0 mm broad at pileus margin, 1 mm centrally, 0.5–2.0 mm at stipe apex, off-white and pinkish with age (near 5B2), sub-thick, distant; edges roughened, at times with some intervenous connections; lamellulae 0.5 mm long. STIPE 81–200 mm × 1.5–2.0 mm (centrally and at apex), broadening gradually to 2–7 mm at base, off-white, slightly graying upon pressure, fragile, smooth macroscopically but finely longitudinally fibrillose under hand lens; basal mycelium white. ODOR none; TASTE not obtained.

SPORE PRINT dull salmon pink on stipe apex. SPORES distinctly 4–5-sided, stellate in all views with extremely elongated corners and concave sides, large, 22.6–36.7 × 19.4–34.5 µm, ($\bar{x}$ = AL 28.52 ± 2.84 × 27.16 ± 3.0 µm, E = 0.9–1.34, Q = 1.05 ± 0.08, L-D (-)2.64–6.56 µm, AL-D 1.36 ± 1.92 µm; n/4 =82). BASIDIA; broadly cylindric with parallel sides and a rounded base, 38.5–66.0 × 16.5–22.9 µm, ($\bar{x}$ = 49.07 ± 4.95 × 19.81 ± 1.31 µm, E = 1.91–3.34, Q = 2.48 ± 0.31; n/4 = 71); distinctly cyanophilic in Amman's; 2–4 sterigmate; sterigmata small and indistinct. LAMELLAR TRAMA HYPHAE subparallel, some with distinct globules as seen in Amman's and KOH/Phloxine, broad with long hyphal cells, 214.5–891.1 × 9.8–32.6 μm. CHEILOCYSTIDIA abundant, forming a sterile gill edge, broadly clavate to napiform and with distinct granular contents, colorless but staining reddish in KOH/Phloxine, 39.6–104.5 × 9.1–35.7 μm. PLEUROCYSTIDIA absent. PILEIPELLIS an entangled layer of hyphae on the umbo area; subpellis not differentiated from the suprapellis and intergrades imperceptibly with the pileus trama; terminal cells cylindric to cylindro-clavate, moderately broad and long, too few to measure. PILEUS TRAMA HYPHAE with abundant globules or granules as seen in Amman's and in KOH/Phloxine; broad with long hyphal cells, 192.9–427.5 × 7.9–25.9μm. STIPITIPELLIS with rare to scattered clusters of hymenial elements, otherwise a cutis; stipe trama very broad. PIGMENTATION suggestively cytoplasmic, occasionally with minute patches of material adhering to the inner hyphal walls of the pileipellis near the subpellis region. CLAMP CONNECTIONS present but inconspicuous at the base of the basidioles, basidia, and cheilocystidia, and on the pileipellis hyphae.

MATERIAL STUDIED: GUYANA. REGION 8 POTARO-SIPARUNI: Pakaraima Mountains, Upper Potaro River, 20 km east of Mt. Ayanganna, near confluence of Potaro River and Alukyadongbaru Creek, Ayanganna airstrip, growing in shelter of standing snag, 17 May 2000, *Aime 968* (BRG, LSU), near Potaro base camp, 14 June 2000 *Aime 1230* (BRG, LSU), *Dicymbe* Plot 3, on soil, 18 May 2001 *Aime 1466* (BRG, LSU), *Dicymbe* Plot 2, sheltered in hollow of standing snag, 22 May 2001, *Aime 1563* (BRG, LSU), Mixed Forest Plot 1, 15 June 2001 *Henkel 8147* (BRG, HSU), Mixed Forest Plot 3, 8 June 2004, *Henkel 8663* (BRG, HSU).

HABIT, HABITAT AND RANGE: Solitary to scattered on leaf humus or soil, at times sheltered at base of standing snags or under logs in mixed tropical rainforest or in forest dominated by *Dicymbe corymbosa*. Known from central and northeastern South America (Brazil, Guyana), Caribbean Central America (Belize) and the Greater and Lesser Antilles (Puerto Rico, Trinidad).

REMARKS—*Inocephalus dragonosporus* can be recognized by its narrowly conic pileus with a hyaline to white nipple that disappears with age (Fig. 1c), extremely long and narrow stipe measuring 81–200 mm × 1.5–2 mm (Fig. 1a), unique, very large, stellate spores with 4–5 distinctly protruding angles like the corners of a pagoda (Fig. 2a), large, broadly cylindric basidia with nearly parallel sides and rounded basal ends (Figs. 2b-c), clavate colorless cheilocystidia (Fig. 2d), and small clamp connections. Heretofore, all published illustrations of these distinctive features have been line drawings. Cheilocystidia were not mentioned or diagrammed by Horak (1977, 1982) or by Singer (1965).

Rhodophyllus pinnus Romagn. from Madagascar is the only other species remotely similar to *I. dragonosporus* and it can be recognized by its larger pileus (30–40 × 35–40 mm), smaller basidia (32–48 × 11.5–15 μm), lack of hymenial cystidia, and much smaller spores ((12) 14–16.5 × 10–15 μm).

Of the more than 50 species of *Entolomataceae* thus far recorded from the Pakaraima Mountains (Largent et al. 2007, and unpublished), *Entoloma* *viscaurantium* E. Horak & Singer is the only species whose spore shape remotely resembles that of *I. dragonosporus*. However, *E. viscaurantium* can easily be differentiated by its viscid, orange brown pileus, lamellae that are pale pinkish yellow at first, then yellowish-orange (4A7–8), a much shorter stipe, and smaller spores (7.8–13.6 × 7.2–12.8 µm).

Acknowledgments

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Reclassification of *Bremia domingensis* to the genus *Plasmopara* as *P. domingensis* comb. nov.

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Abstract — In this study, the isotype of *Bremia domingensis* on *Parthenium hysterophorus* is carefully investigated, described and illustrated based on morphological characteristics. It is concluded that the species is misplaced in *Bremia* but is a member of *Plasmopara*. Therefore, the new combination *Plasmopara domingensis* is proposed for this pathogen.

Key words — branching pattern, downy mildew, sporangia, taxonomy

Introduction

The family *Asteraceae* is one of the largest families of dicotyledons, within which many genera are host plants of parasitic fungi such as *Albuginaceae, Peronosporaceae, Erysiphaceae* and *Uredinales*. Of the numerous genera within the *Peronosporaceae, Bremia* and *Plasmopara* are most common on the *Asteraceae*. In the past, the taxonomy has been based primarily on subtle differences in the shape or dimensions of the sporangia and upon the host plant or assumed host range. This sometimes resulted in confusion regarding identifying the species or even the genus of a causal agent. During a taxonomic revision of *Bremia* species, we examined the type material of *Bremia domingensis*, a downy mildew pathogen on *Parthenium hysterophorus* belonging to the *Asteraceae*. The morphological characters of the fungus do not agree with *Bremia*. A new combination in *Plasmopara* is proposed here.

Materials and methods

Herbarium specimens from the collections of U.S. National Fungus Collections, USA (BPI) were morphologically examined. For morphological analysis, specimens were moistened with 70% alcohol and fungi were transferred to 60% lactic acid on a slide. The microscope preparations were warmed and examined in brightfield- and DIC- light microscopy. Measurements were performed at 1000× for sporangia and 100–1000× for other organs.

Results

Description of *Bremia domingensis* – LESIONS present on leaves, poly-angular, 2–5 mm diam., vein-limited, sometimes covering larger areas by coalescing. DOWN hypophyllous, whitish, consisting of agglomerated sporangiophores, felt-like, dense. HAUSTORIA intracellular, globose, unbranched, symmetrical, 4–7 µm diam., surrounded by sheaths of about 1 µm thickness. SPORANGIOPHORES emerging through stomata, hyaline, straight to slightly curved, slender, 300–420(–550) µm long; trunk straight to slightly curved, 140–250(–320) µm long, 8–13 µm wide, basal ends not differentiated to slightly bulbous, callose plugs sometimes present; branches arising at right angles to the main axis, not broadening towards the ramifications, monopodial, of 4 to 6(–7) orders, straight to slightly curved, callose plugs often present. ULTIMATE BRANCHLETS straight to slightly curved, (6–)8–13(–17) µm long, 1.5–3 µm wide at the base, callose plugs mostly absent; tip truncate or cup-like, rarely round. SPORANGIA hyaline, broadly ellipsoidal to subglobose, uniform in size, 15–21.3 µm long (mean=18.6 µm), 13.8–17.5 µm wide (mean=15.7 µm), length/width ratio (1.09–)1.15–1.26 (mean=1.19), greatest width median or sub-median, tip and base round; pedicel absent or having a slightly eccentric scar visible at the place of attachment; apical dehiscence apparatus 3–4 µm wide, 0.8–1.3 µm thick. RESTING ORGANS not seen.

Discussion

In subfamily *Asteroideae* of the *Asteraceae,* three genera with branched sporangiophores, *Bremia, Paraperonospora* and *Plasmopara,* are known to cause downy mildew. *Plasmopara* and *Paraperonospora* species occur on more hosts than do *Bremia* species. Sporangiophores not broadening towards the ramifications (Fig. 1A, C) distinguished the isotype material of *Bremia domingensis* from *Paraperonospora.* Besides, in *Paraperonospora* the papilla is mostly absent or observed only as reminiscent of a dehiscence apparatus in some species (Constantinescu 1989), but it is clearly visible on the specimen examined (Fig. 1F–H), supporting that this fungus is not to be placed in *Paraperonospora.*

The most useful morphological characteristics for distinguishing between *Plasmopara* and *Bremia* are the more pronounced monopodial branching pattern of the sporangiophores in *Plasmopara* and the inflated distal end of the sporangiophore branches, carrying the regular aggregated ultimate branchlets, in *Bremia* (Thines 2006). In *Bremia domingensis,* the branches and their subdivisions branched monopodially at right angles. The uninflated ends of the branches and the presence of a dehiscence apparatus places *B. domingensis* in *Plasmopara.* Two new genera, *Novotelnova* (Voglmayr & Constantinescu 2008)

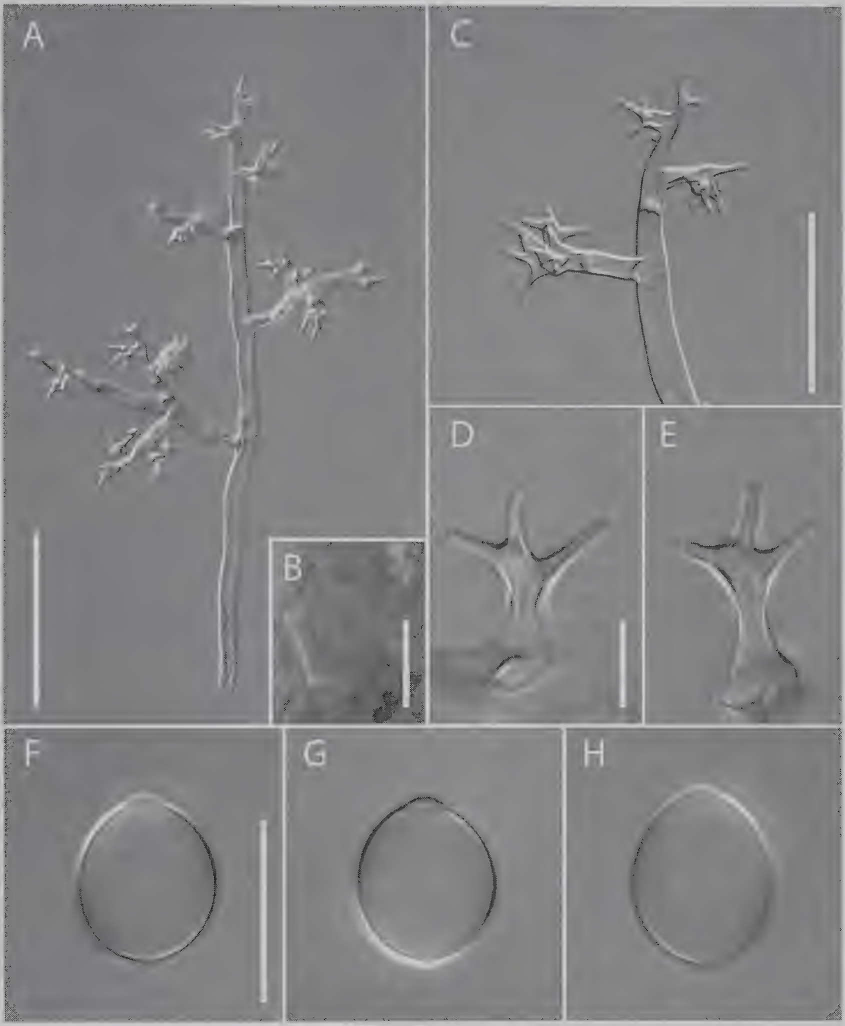

Fig. 1. *Bremia domingensis* on *Parthenium hysterophorus.* A: Sporangiophore; B: Haustorium; C: Branches; D & E: Ultimate branchlets; F, G & H: Sporangia. Scale bars = 100 µm for A, 10µm for B, D & E, 50 µm for C, 20µm for F, G & H. Source: BPI 845215 (isotype).

and *Protobremia* (Voglmayr et al. 2004), have recently been introduced to accommodate the pathogens on *Scorzonera* and *Tragopogon,* respectively, in the subfamily *Cichorioideae* of the family *Asteraceae.* The present fungus differed from the former genus by uninflated distal ends of the sporangiophores and from the latter by sporangiophores not broadening upward.

When Ciferri (1957) described *B. domingensis* on *Parthenium hysterophorus,* he noted that "The morphology of our specimen agrees well with *B. lactucae* Regel *sensu lato*", and supposed that "this fungus is specialized on the new host plant as a new geographical race of the genus". Later, based on the wide species concept of the genus, Evans (1987) proposed to treat it as a synonym under *B. lactucae.* In the present study, however, we show that the morphological characters of the type material are clearly different from *B. lactucae,* but agree with that of *Plasmopara.*

Taxonomy

Due to the findings outlined above, it is concluded that the species described as *Bremia domingensis* is misplaced in the genus *Bremia,* but belongs to the genus *Plasmopara* instead. Therefore, a new combination in *Plasmopara* is proposed.

Plasmopara domingensis (Cif.) Y.J. Choi & H.D. Shin, **comb. nov.** FIG. 1

MycoBank # MB 511835

Basionym: *Bremia domingensis* Cif., Sydowia 10: 131, 1957 ('1956').

SPECIMENS EXAMINED – **DOMINICAN REPUBLIC:** Cibao Valley, Santiago Province, Hato del Yaque., in living leaves of *Parthenium hysterophorus* L., 1930-1931, R. Ciferri (*R. Ciferri Micoflora Domingensis Exsiccata 357,* holotype; *BPI 845215* & *BPI 786230,* isotypes).

Known distribution: only from the type collection.

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Wardomycopsis litoralis, a new soil-borne hyphomycete from Spain

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Abstract — The new hyphomycete *Wardomycopsis litoralis*, isolated from a soil sample in Spain, is described and illustrated. This fungus is characterized mainly by conidiogenous cells that show distinct terminal annellations and conidia with a median germ slit running longitudinally. It can be differentiated from the other species of the genus mainly by conidial morphology. Sequence analysis of the internal transcribed spacer regions and the 5.8S ribosomal RNA gene confirmed this hypothesis and revealed a close genetic relationship of *W. litoralis* with the genera *Wardomyces* and *Scopulariopsis*.

Key words — soil fungi, conidial fungi, molecular phylogeny.

Introduction

During a continued survey of soil-borne microfungi from different geographical areas of Spain, we recovered several interesting fungi from the Mediterranean region. One of these was considered to belong to the anamorph genus *Wardomycopsis* Udagawa & Furuya, but its morphological features did not match those of the three other species of the genus (Udagawa & Furuya 1978, Taylor & Hyde 2003). This fungus is therefore proposed here as a new species. To confirm our hypothesis and to infer the phylogenetic relationships between the new fungus and other species of *Wardomycopsis* and other related genera, we compared the sequence of internal transcribed spacer (ITS) regions including the 5.8S ribosomal RNA (rRNA) gene.

Materials and methods

The samples were recovered from beach soil from Vinarós, Castelló (Spain). This geographical area has an altitude of 35 m, an average annual temperature of 10.4–25°C and an average annual rainfall of 12–62 mm. Soil samples free of organic matter (A_o horizon) were introduced separately into sterilized polyethylene bags, closed with rubber bands and labelled. In the laboratory, they were stored in a refrigerator at 4–7°C until they were processed. Soil suspensions were cultured on the selective medium Dichloran Rose-Bengal chloramphenicol agar (Oxoid, United Kingdom) with cycloheximide (10 µg/mL) and incubated at 23–25 °C. In order to study macro- and microscopic features, the developed fungi were transferred, using a sterile dissection needle, to three different media, i.e. potato carrot agar (PCA; 20 g potatoes, 20 g carrots, 20 g agar, 1 L sterile distilled water, home-made), oat meal agar (OA; 30 g flakes, 20 g agar, 1 L sterile distilled water, home-made) and potato dextrose agar (PDA; Difco Laboratories, Detroit, Michigan), and incubated at 25°C in darkness. Growth temperature was determined on PDA at 25, 37 and 40°C. For the observations to the optical microscope the fungal isolates were mounted in lactic acid. Micrographs were obtained with a Leitz Dialux 20 EB microscope and a Jeol JSM-6400 scanning electron microscope.

Molecular study

The strains included in the phylogenetic study are shown in Table 1. The ITS regions and 5.8 rRNA gene were sequenced using ITS-5 and ITS-4 primers. DNA extraction, amplification and sequencing were performed as described in Solé et al. (2002). The sequences were aligned using the Clustal X (version 1.81) computer programme for multiple sequence alignment (Thompson et al. 1997). Cladistic analyses using the neighbour-joining method (Saitou & Nei 1987) were performed with the MEGA 2.1 computer program (Kumar et al. 2001). The tree was constructed using the Kimura-2-parameter distance model (Kimura 1980) with pair-wise deletion of gaps. The robustness of branches was assessed by bootstrap analysis with 1000 replicates. The tree was rooted with a sequence of *Petriella setifera* (Alf. Schmidt) Curzi obtained from the GenBank.

Table 1. List of species included in the molecular analysis

Species	Strain	Source	EMBL accession no.
Microascus trigonosporus	CBS 665.71	Soil, USA	AM774156*
Scopulariopsis brevicaulis	----	---	AJ853776
Scopulariopsis chartarum	FMR 3997	Soil, Spain	AM774160*
	---	---	AY625066
Wardomyces humicola	CBS 369.62 (T)	Soil, Canada	AM774157*
Wardomyces inflatus	CBS 216.61 (T)	Soil, Canada	AM774155*
Wardomycopsis humicola	FMR 3993	Soil, Spain	AM774159*
Wardomycopsis litoralis	CBS 119740 (T)	Soil, Spain	AM774158*
Petriella setifera	---	---	AF043596

CBS, Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands; FMR, Facultat de Medicina de Reus, Spain; T, ex-type culture; *, newly generated sequences for this study.

Taxonomic description

Wardomycopsis litoralis Silvera, Gené, Cano & Guarro, **sp. nov.** **Figs 1, 2**

MycoBank MB511237

Ad fungos conidiales, hyphomycetes pertinens. Coloniae in vitro restrictae, fuscae. Conidiophora semi-macronemata, septata, laevia, hyalina vel subhyalina, simplicia vel irregulariter ramosa, up to 20 µm longa. Cellulae conidiogenae hyalinae vel leviter coloratae, laeves, ampulliformes, 5.5–7.5 × 3.5–5 µm. Conidia sicca, acrogena, plerumque breve catenulata, unicellularia, obovoidea vel late ellipsoidea, 5–7 × 3–4.5 µm, primum pallida, deinde olivaceo-brunnea, crassitunicata, laeves, cum fisura mediana. Teleomorphosis ignota.

Holotype: Spain, Catalunya, Castelló, Vinarós: isolated from beach soil, Jul. 2005, J. Gené and A.M. Stchigel (IMI 394093). Cultures ex type: CBS 119740 and FMR 8876.

Etymology: from the Latin *litoralis,* referring to the geographical region where the fungus was collected.

Conidial fungi, hyphomycetes. Colonies in vitro restricted, cottony to powdery, pale to dark grey. Mycelium sparse, superficial or immersed, hyaline to pale yellowish brown, composed of mostly flexuous, branched,septate, smooth-walled hyphae, 1.5–3 µm diam, often forming funicles. Conidial structures as annellidic conidiogenous cells borne singly along the aerial or prostrate hyphae, or in small divergent groups on short conidiophores. Conidiophores semi-macronematous, mononematous, septate, smooth-walled, hyaline to subhyaline, simple or branched, up to 20 µm long. Conidiogenous cells

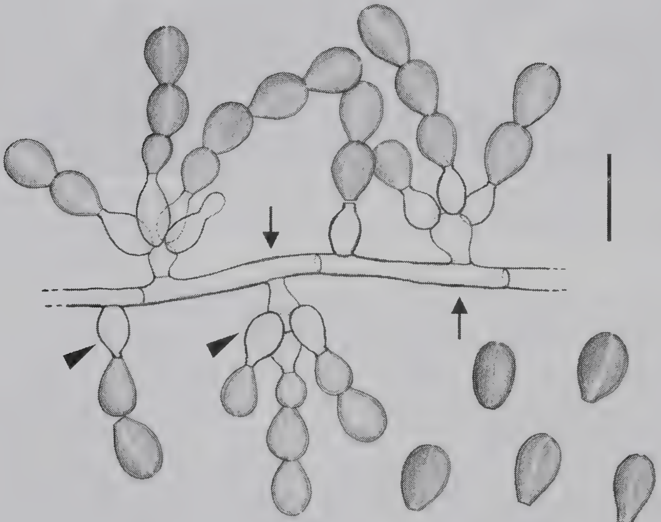

Fig. 1. *Wardomycopsis litoralis,* CBS 119740. Conidiophores (arrows), conidiogenous cells (arrowheads) and conidia with germ slit. Scale bar: 10 µm.

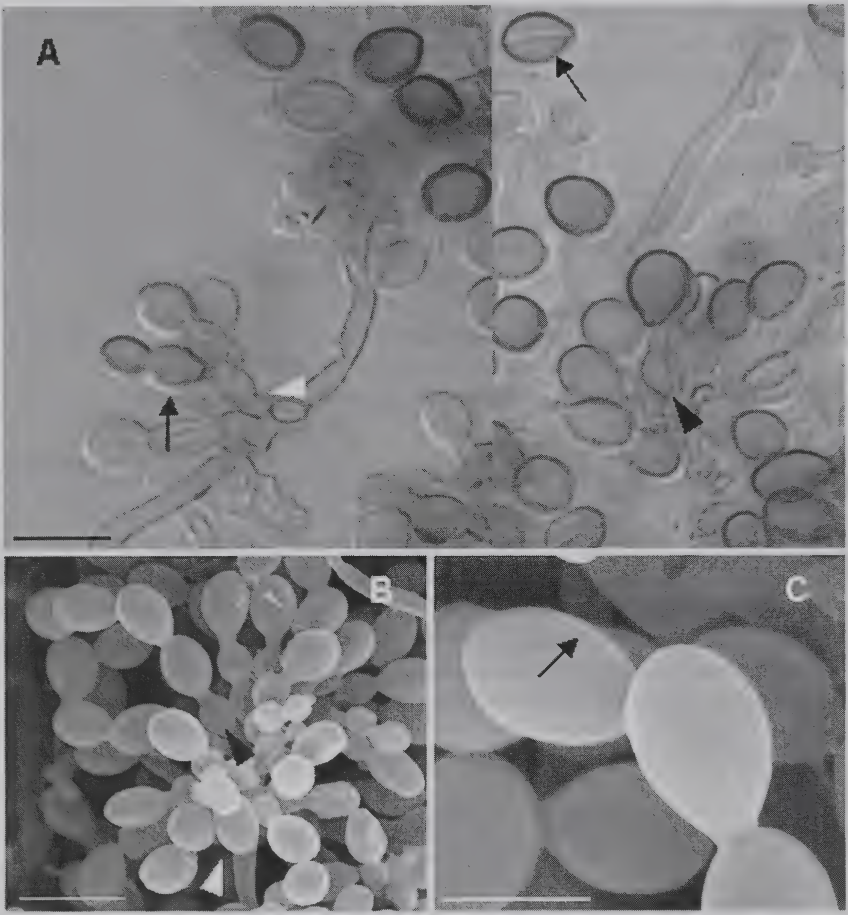

Fig. 2. *Wardomycopsis litoralis*, CBS 119740. A, B. Conidiophores (white arrowheads), conidiogenous cells (black arrowheads) and conidia with germ slit (arrows). C. Detail of a conidia with germ slit (arrow). Scale bars: A–C = 10 µm.

hyaline to subhyaline, smooth-walled, ampulliform, 5.5–7.5 × 3.5–5 µm, with a narrow terminal neck formed by successive annellations. CONIDIA dry, acrogenous, borne in basipetal succession as a curved short chain up to 4–5 conidia, obovoid or broadly ellipsoidal, 5–7 × 3–4.5 µm, truncate at the base, subhyaline when young, dark olivaceous when mature, thick- and smooth-walled, with a median longitudinal germ slit. Teleomorph unknown.

CULTURAL CHARACTERISTICS: The optimal growth was at 25ºC. At this temperature and after 14 days of incubation, colonies on OA were 14–25 mm diam, cottony at centre to powdery at outwards, dark grey, margin diffuse; reverse colourless. Colonies on PCA were 17–19 mm diam, powdery, dark grey; reverse colourless. Colonies on PDA were 13–16 mm diam, velvety, raised, slightly fasciculate at the centre, radially folded, white at first, becoming pale grey, margin slightly lobed; reverse colourless. At 37°C the fungus grew more slowly than at 25°C, with colonies attaining a diameter of 6–10 mm at 14 days. The fungus was unable to grow at 40°C. The best sporulation was on OA and PCA at 25°C.

Additional specimens examined: *Wardomycopsis humicola*. Canada, Ontario, Guelph: from soil, Aug. 1966, *G.L. Barron* (CBS 487.66 type strain). Spain, Catalunya, Girona, Pals: from river sediments of the River Ter, Jun. 1991, J. Gené and K. Ulfig (FMR 3993).

Discussion

Wardomycopsis is one of the anamorph genera related to *Microascaceae* (Malloch 1970, von Arx et al. 1988). This genus is characterized by dark, globose, thick-walled conidia with germ slits that form short chains on annellidic conidiogenous cells (Udagawa & Furuya 1978). *Wardomycopsis* shows morphological similarities with *Wardomyces* F.T. Brooks & Hansf. and *Scopulariopsis* Bainier, but the members of *Wardomyces* produce single conidia with germ slits from polyblastic conidiogenous cells and those of *Scopulariopsis* produce long catenate conidia without germ slits (Domsch et al. 1980). Limits between *Wardomycopsis* and *Scopulariopsis* are still unclear (Barron 1966; Domsch et al. 1980).

The other currently accepted *Wardomycopsis* species are the type species — *W. inopinata* Udagawa & Furuya — and *W. humicola* (G.L. Barron) Udagawa & Furuya and *W. trachycarpicola* Joanne E. Taylor et al. (Udagawa & Furuya 1978, Taylor & Hyde 2003). They differ from *W. litoralis* mainly by their conidial morphology. *W. trachycarpicola* also differs from the other *Wardomycopsis* species by the absence of conidial chains. In addition, we found that *W. humicola*, which otherwise resembles *W. litoralis* morphologically, was unable to grow at 37°C. The diagnostic morphological features of the four *Wardomycopsis* species are keyed out below.

Figure 3 shows the phylogenetic tree inferred from the analysis of the ITS sequence of *Wardomycopsis* strains and species in other genera morphologically close to *Wardomycopsis*. Unfortunately, *W. inopinata* and *W. trachycarpicola* are not included in this phylogenetic analysis because neither strain is available in any reference culture collections. Although the *W. humicola* type strain was examined morphologically and found to be identical to the protologue and strain FMR 3993, its sequence is considerably shorter (ca. 300 bp) than the rest and so also could not be included in the tree. However, the type strain sequence was informative enough to show that it was genetically very close to FMR 3993, the isolate of *W. humicola* that is included in the analysis. The tree topology supports *W. litoralis* as an independent species. Three main clades were clearly distinguished in the tree. The first clade (with 87% bootstrap support) includes the strains of *Scopulariopsis chartarum* (G. Sm.) F.J. Morton & G. Sm., *Microascus trigonosporus* C.W. Emmons & B.O. Dodge (also presenting a *Scopulariopsis* anamorph), and *Scopulariopsis brevicaulis* (Sacc.) Bainier. The second clade (99% bootstrap value) groups the two *Wardomyces* species, i.e., *Wa. humicola* Hennebert & G.L. Barron and *Wa. inflatus* (Marchal) Hennebert. The third clade (with 83% bootstrap support) includes two *Wardomycopsis* strains — one corresponding to *W. humicola* and the other to *W. litoralis* — although they appear fairly distant from each other.

Although we think *Wardomycopsis litoralis* is properly characterized and clearly justified by evident morphological traits, molecular analysis only partially supports the new taxon. This may be due to the fact that only few strains were included in the analysis and that the ITS region is not the most appropriate marker for inferring phylogenetic differences, as has been noted for other genera such as *Aspergillus* P. Micheli ex Link (Balajee et al. 2007), *Pseudallescheria* Negr. & I. Fisch. (Gilgado et al. 2005), and *Phaeoacremonium* W. Gams, Crous & M.J. Wingf. (Mostert et al. 2005). The lack of available

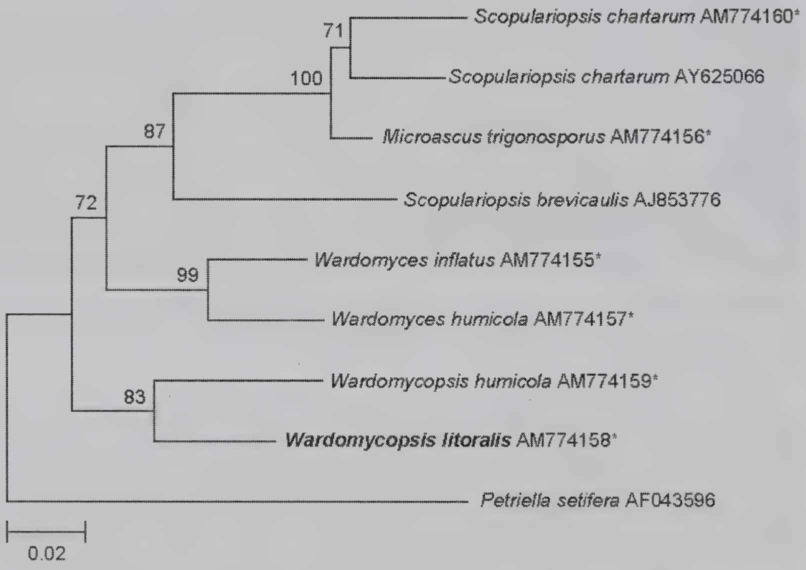
71
100
87
72
99
83
Scopulariopsis chartarum AM774160*
Scopulariopsis chartarum AY625066
Microascus trigonosporus AM774156*
Scopulariopsis brevicaulis AJ853776
Wardomyces inflatus AM774155*
Wardomyces humicola AM774157*
Wardomycopsis humicola AM774159*
Wardomycopsis litoralis AM774158*
Petriella setifera AF043596
0.02

Fig. 3. Neighbour-joining tree based on Kimura 2-p corrected nucleotide distances among the ribosomal internal transcribed spacer (ITS) regions and 5.8S rDNA sequences of the nine strains listed in Table 1. Branch lengths are proportional to distance. Bootstrap replication frequencies (1000 replications) are indicated at the internodes.* Newly generated sequences in this study.

reference strains of the species studied here constitutes an important limitation to performing a wider study. In order to establish more clearly the boundaries among these genera, we are currently designing primers to amplify other genes that could be more phylogenetically informative.

Key to species of *Wardomycopsis*

1a. Conidia not in chains.................................... *W. trachycarpicola*
1b. Conidia in short chains 2

2a. Conidia globose to subglobose, 4–5 µm diam .... *W. inopinata*
2b. Conidia otherwise.. 3

3a. Conidia ellipsoidal to short cylindrical, 4–5 × 2.5–3 µm. No growth at 37°C .... *W. humicola*
3b. Conidia obovoid to broadly ellipsoidal, 5–7 × 3–4.5 µm. Growth at 37°C .... *W. litoralis*

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Llimoniella muralicola sp. nov. (*Ascomycota, Helotiaceae*) on *Protoparmeliopsis muralis* from western Turkey

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Abstract — *Llimoniella muralicola* is described as new from the areoles of *Protoparmeliopsis muralis* in western Turkey. It differs from the other members of the genus in the shorter and relatively narrow ascospores. The new species is the first *Llimoniella* species reported on *Protoparmeliopsis muralis.*

Key words — biodiversity, lichenicolous fungi, lichens

Introduction

The genus *Llimoniella* was originally introduced for two closely related species, *L. adnata* and *L. scabridula*, growing as parasites in epigeous lichen communities over gypsaceous soils (Hafellner & Navarro-Rosinés 1993). Some of the subsequent species, which were described under *Llimoniella* such as *L. fuscoatrae*, *L. neglecta*, *L. pubescens* and *L. stereocaulorum*, were transferred to *Rhymbocarpus* and *L. groenlandiae* was transferred to *Unguiculariopsis* by Diederich & Etayo (2000).

After the synopsis of the genera *Skyttea*, *Llimoniella* and *Rhymbocarpus* was published by Diederich & Etayo (2000), two more species of *Llimoniella* were described: *L. caloplacae* by Kondratyuk et al. (2006) and *L. fuscatae* by Hafellner & Obermayer (2007). Here, one more species of *Llimoniella* is described on *Protoparmeliopsis muralis* from Turkey, raising the number of species in the genus to eight.

Material and methods

The type material of the new species is deposited in the herbarium of Erciyes University, Science& Art Faculty, Biology Department, Kayseri. Specimens were examined with an Olympus BH-2 research microscope fitted with Nomarski differential interference contrast optics and a drawing tube. Photomicrographs were prepared on a Nikon Eclipse 80i. Sections were prepared by hand and examined in I (Lugol's iodine, with [K/I] and without [I] pre-treatment with 10% KOH), 10% KOH alone, and water. The exciple structure was examined in C (commercial bleach). Ascospore measurements were made in water and 10% KOH; the extreme values outside the main range are given in parentheses. The length/breadth (l/b) ratio of the ascospores is given in the same way.

The species

Llimoniella muralicola Halici, **sp. nov.** FIGURE 1

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> Llimoniella *species ascomatibus superficialibus, 0.3–0.6 mm diam., nigra, margine prominenti. Asci unitunicati, octospori, 28–32 × 6–7 µm, parietibus apicaliter non incrassates, non amyloideis. Ascosporae hyalinae, unicellulares, ellipsoideae, 7–8(–9) × (2.5–)3–4(–5) µm magnae, non halonatae. Habitat supra thalium Protoparmeliae muralae.*
>
> Typus: Turkey, Denizli, Dikmen Village, Babadağ, 38°43'N, 28°52'E, alt. 2065 m, on thallus of *Protoparmeliopsis muralis* on siliceous rocks, 14 June 2007, leg. M. Kocakaya (MGH 0.5268 – holotypus).
>
> Etymology: The epithet "*muralicola*" refers to the host *Protoparmeliopsis muralis.*

Description: Lichenicolous, on the thallus of *Protoparmeliopsis muralis*, causing slight discolorations in the infected areoles, mildly pathogenic. Ascomata at first perithecioid, gradually opening at the apex and becoming apothecioid, dispersed on the host thallus, sometimes loosely aggregated in groups of 2–4, superficial, matt black, initially ± closed, soon applanate, 0.3–0.6 mm in diam., concave to slightly convex, margin prominent, scabrous. Exciple persistent, with a dark reddish brown pigment, K + violet-red, 30–50 µm thick; composed of ± isodiametric cells of 4–6 µm diam., except the outer layer which consists of radiating hyaline cells reaching to 20 µm in length. Subhymenium hyaline. Hymenium colourless, without a greenish tinge, K –, 40–50 µm tall, KI –, no distinct epithecium and hypothecium developed. Paraphyses hyaline, c. 1.5–2.5 mm thick, occasionally branched, easily separating, apically slightly thicker, 2.5–3.5 µm, septate. Asci elongate-clavate, very shortly stalked, apically not thickened, rarely hardly thickened, 8-spored, KI, I –, 28–59 × 6–9 µm. Ascospores irregularly biseriate or uniseriately arranged in the asci, ellipsoid, hyaline, straight or curved, non-septate, generally 2-guttulate, sometimes multiguttulate, smooth-walled, 7–8(–9) × (2.5–)3–4(–5) µm (n = 32), l/b = (2–)2.35–2.7(–3.2). Conidiomata not observed.

Ecology and distribution: The species appears to be mildly pathogenic as noted from discolorations in the infected areoles of the host. The new species is known from one locality from the western part of Turkey. As the host species has a wide distribution in the world, the species should be searched for elsewhere.

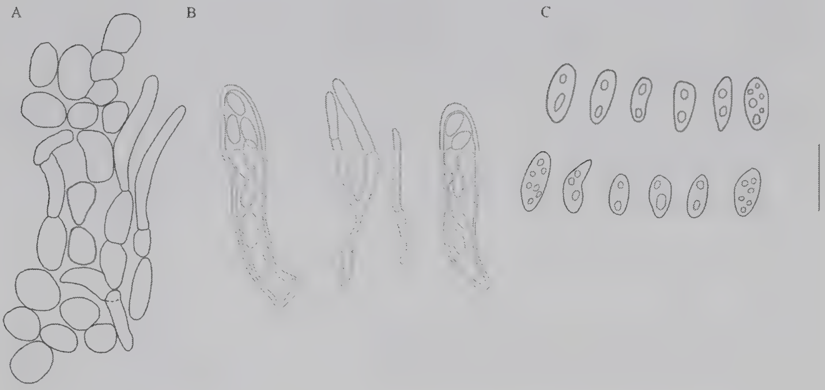

Fig. 1. ***Llimoniella muralicola*** (holotype).
A, Exciple; B, Asci and paraphyses; C, Ascospores
Scale = 10 μm

OBSERVATIONS: *Llimoniella muralicola* is the first species of *Llimoniella* reported on *Protoparmeliopsis muralis*. The new species seems to be most closely related to *L. scabridula* (Müll.Arg.) Nav.-Ros. & Hafellner, which occurs on terricolous *Acarospora* species (Hafellner & Navarro-Rosinés 1993). However, *L. muralicola* differs from this species in having shorter and narrower ascospores [7–8(–9) × (2.5–)3–4(–5) μm vs. (8–)9–11 × 4–5(–6) μm]. *L. adnata* Hafellner & Nav.-Ros., known from terricolous *Placidium squamulosum* (Hafellner & Navarro-Rosinés 1993), also has longer and wider ascospores [9–13 × (5–)6–7 μm vs. 7–8(–9) × (2.5–)3–4(–5) μm] and paraphyses that are pale blue pigmented in the end cells. *L. fuscatae* Hafellner & Obermayer, a recently described species on *Acarospora fuscata* from Austria (Hafellner & Obermayer 2007) has obviously larger and wider ascospores [9–12 × 5.5–7.5 μm vs. 7–8(–9) × (2.5–)3–4(–5) μm]. Another recently described species, *L. caloplacae* S.Y.Kondr. & Khodos. on *Caloplaca borysthenica* from Ukraine (Kondratyuk et al. 2006) has 0–1-septate ascospores which are obviously longer [9.5–13(–16) × 2.85–3.5(–4) μm vs. 7–8(–9) × (2.5–)3–4(–5) μm].

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Cercosporoid hyphomycetes on hosts of the *Annonaceae:* *Cercospora annonaceae* and *Isariopsis annonarum* revisited

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Abstract — Type material of *Cercospora annonaceae* and several collections assigned to this species by C. Chupp have been re-examined. The status of this species as a member of the genus *Stenella* is confirmed, but most collections in Chupp´s herbarium referred to as *C. annonaceae* proved to be misidentified, and pertain to *Isariopsis annonarum*, herein reallocated to *Pseudocercospora*, and the new species *Phacellium annonae-cherimoliae*. A key to 23 cercosporoid hyphomycete species on hosts belonging to the *Annonaceae* is provided, and the taxonomy of the species concerned is briefly discussed. The following new combinations are proposed: *Pseudocercospora annonarum*, *P. asiminae* and *P. oblecta*. Furthermore, a revised, detailed description of *Pseudocercospora annonae-squamosae* is provided.

Key words — anamorphs, cercospora-like, *Annona*

Introduction

Cercospora annonaceae (Hennings 1909) was introduced for a cercosporoid hyphomycete on an unknown member of the *Annonaceae* collected in Brazil. The original data are rather scanty, simply describing hypophyllous caespituli, fasciculate 'hyphae' (i.e. conidiophores), up to 150 × 3.5 µm, septate, and cylindrical-fusiform conidia, 15–35 × 2.5–3.5 µm, 3–7-septate, brown. In his monograph of *Cercospora* Fresen., Chupp (1954) considered this species a coremioid hyphomycete, which has to be excluded from the latter genus. His observations were based on a revision of type material, deposited at the herbarium of the Botanical Garden and Museum in Berlin, Germany (B), and several secondary samples in his own herbarium, now maintained at the Plant Pathology Herbarium of the Cornell University, Ithaca, New York, USA (CUP). Unfortunately the type material at B has been lost. Braun (in Braun

& Mel'nik 1996) detected and examined syntype material of this species deposited at the Russian herbarium LEP. Hennings (1908) cited the following details for the type collection: 'Agua Branca in foliis Anonaceae. Majo 1903, no. 738' ['Agua Branca, São Paulo, Anonaceae, A. Puttemans, No. 738, May 10- (16?), 1903' is the altered version given in Chupp (1954), who examined this material]. The label of the syntype material at LEP deviates and reads as follows: 'Pará, *Annonaceae*, V 1903, Puttemans.' The whole context of the protologue and the labels concerned suggest the locality Agua Branca (or Agua Branca do Paulinho?) in the state of Pará, in which also a city with the name São Paulo exists. Braun (Braun & Mel'nik 1996) reallocated *C. annonaceae* to *Stenella* Syd., since the only discernable cercosporoid hyphomycete found in the syntype material at LEP was a member of the latter genus. However, in the latter material only solitary conidiophores arising from superficial hyphae were found, i.e. fasciculate conidiophores were lacking, which was in conflict with the original description (Hennings 1908) as well as Chupp´s (1954) comments on this species, and raised the question whether a single polymorphous or two different cercosporoid taxa had been involved. Therefore, herbarium specimens referred to as *C. annonaceae* by C. Chupp have been re-examined in order to clarify his taxonomic decision and concept.

Materials and methods

The collections examined were described, mounted in distilled water, using oil immersion (bright field and phase contrast), but without any staining, by means of standard light microscopy (Olympus BX 50, Hamburg, Germany). 30 measurements (× 1000 magnification) of conidia and other structures were made, with the extremes given in parentheses. The collections examined are deposited at the herbaria CUP and W (abbreviations according to Holmgren et al. 1990).

Taxonomy

The examination of four specimens from CUP referred to as *C. annonaceae* by C. Chupp revealed them to represent several distinct taxa. A single collection from Brazil on *Annona reticulata* proved to be a member of *Stenella* conspecific with *C. annonaceae*, a specimen from Venezuela on *A. squamosa* belongs to *Isariopsis annonarum* [≡ *Passalora annonarum*], and another one from Mexico on *A. cherimolia* has to be described as new species of *Phacellium* Bonord.

Stenella annonaceae (Henn.) U. Braun, in Braun & Mel'nik, Mikol. Fitopatol. 30(4): 3, 1996. FIG. 1

≡ *Cercospora annonaceae* Henn., Hedwigia 48: 18, 1908 ['1909'].

Material examined: BRAZIL. Pará, on living leaves of a host belonging to the *Annonaceae* (probably *Annona* sp.), May 1903, Puttemans (LEP), lectotype of *C. annonaceae*, designated here. BRAZIL. Fungos de Minas Geraes, Viçosa-Escola, on living leaves of *Annona reticulata*, 23 Mar. 1930, A.S. Muller (CUP-MG 157).

Leaf spots amphigenous, subcircular to angular-irregular, 1–25 mm diam., sometimes confluent, pale to dull dark brown, later grayish to dingy grayish white, margin indefinite or with a narrow darker border or marginal line. Colonies amphigenous, mainly hypophyllous, inconspicuous, effuse to punctiform, brown to grayish brown. Mycelium internal and external; superficial hyphae emerging through stomata, 1.5–3 µm wide, branched, septate, subhyaline, pale to medium olivaceous, olivaceous-brown or yellowish brown, thin-walled, verruculose. Stromata lacking or small, not very conspicuous, 10–40 µm diam., immersed, brown. Conidiophores solitary, arising from superficial hyphae or in small to moderately large fascicles, loose to usually rather dense, occasionally even coremioid, arising from immersed stromatic hyphal aggregations, erect, unbranched, subcylindrical, straight to somewhat flexuous-sinuous, upper fertile part usually geniculate-sinuous, sometimes strongly so, 20–150 × (2.5–)3–4(–4.5) µm, pluriseptate, pale to dark brown, yellowish brown or olivaceous-brown, smooth, wall thin to slightly thickened (< 1 µm). Conidiogenous cells integrated, terminal and intercalary, 5–20 µm long, occasionally longer, with several conspicuous conidiogenous loci, slightly thickened and darkened, 1–1.5 µm diam. Conidia solitary, subcylindrical-filiform, acicular to narrowly obclavate, 20–100 × 2.5–4.5 µm, 2–8-septate, pale olivaceous, yellowish brown to brown, verruculose, wall thin (ca. 0.5 µm wide), apex obtuse to subacute, base truncate to usually obconically truncate, 1–1.5 (–2) µm wide, hila slightly thickened and darkened.

Comments: The collection on *Annona reticulata* agrees well with the original description of *C. annonaceae* as well as the lectotype of this species in that solitary as well as fasciculate conidiophores are formed. Fasciculate conidiophores were described by Hennings (1908) and observed by Chupp (1954), whereas solitary conidiophores arising from superficial hyphae were found by Braun & Mel'nik (1996) in the lectotype sample.

Phacellium annonae-cherimoliae U. Braun, **sp. nov.** Fig. 2

MycoBank MB 511858.

Phacellio sessili *simile, sed conidiis longioribus et angustioribus, 8–25 × 2–4(–5) µm, 0–1(–2)-septatis, levibus.*

Material examined: MEXICO. Jalapa, Vera Cruz, on living leaves of *Annona cherimolia* (*Annonaceae*), 19 Jul. 1932, O.A. Plunkett 143 (CUP 60731), holotype. Isotype: CUP 39057.

Leaf spots amphigenous, subcircular to angular-irregular, 1–5 mm diam., occasionally confluent, pale to dark brown, later grayish brown to dingy gray,

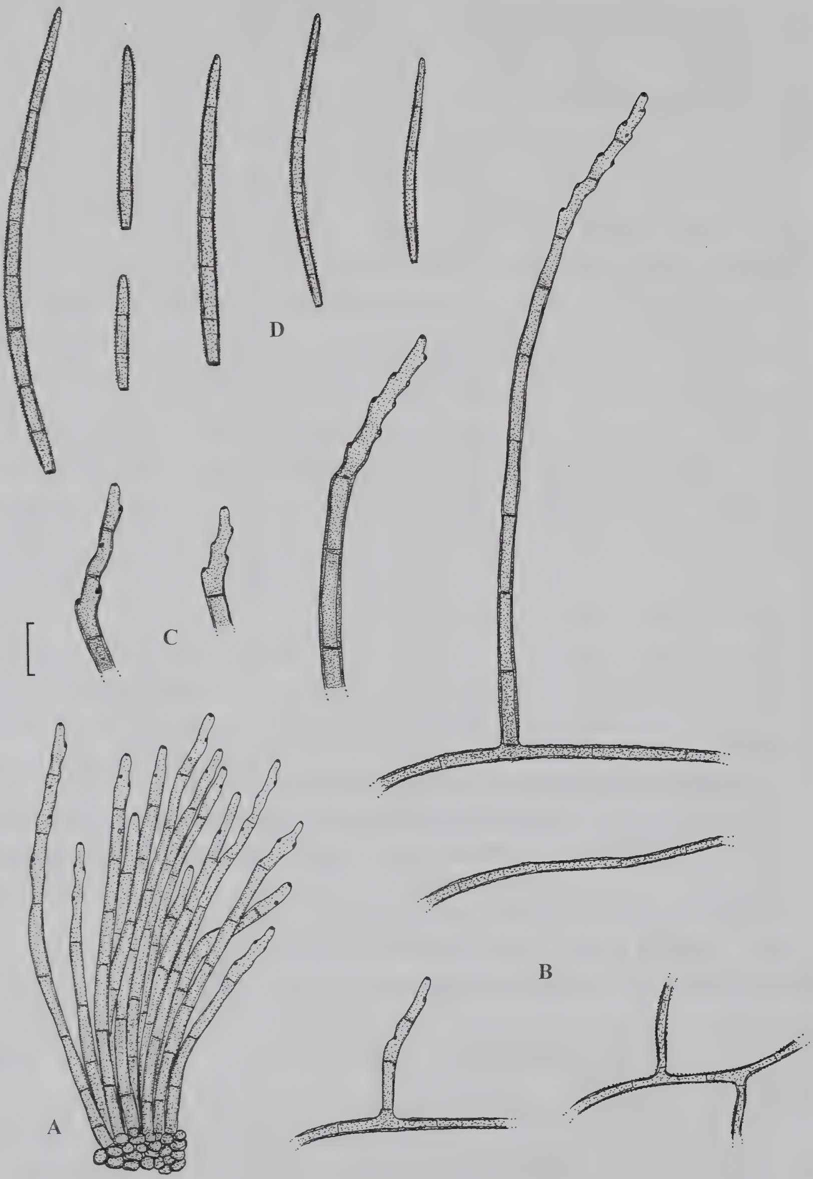


Fig. 1. *Stenella annonaceae*. **A**. Conidiophore fascicle. **B**. Superficial hyphae with or without solitary conidiophores. **C**. Tips of conidiophores with conidiogenous cells. **D**. Conidia. Scale bar = 10 μm (fig. A based on CUP-MG 157, figs B–G based on type material from LEP). U. Braun *del.*

on the lower leaf surface usually much paler, margin conspicuous, narrow, dark brown to blackish. Mycelium internal, forming immersed stromatic hyphal aggregations at the base of synnemata, 20–50 µm diam., brown. Conidiomata synnematous, erect, straight, occasionally slightly curved to sinuous, subcylindrical or somewhat attenuated towards the apex, 150–400 × 10–40 µm, medium brown, composed of a firm stipe of densely appressed parallel threads (conidiophores) and a rather compact, often poorly developed capitulum, barely or only slightly splaying out. Individual conidiophores 1–4 µm wide, pale to mid olivaceous, olivaceous-brown or brown, pluriseptate throughout, smooth, thin-walled. Conidiogenous cells integrated, terminal, intercalary and pleurogenous, 5–20 × 2–5 µm, subhyaline to very pale olivaceous or olivaceous-brown, with a single to usually several conspicuous conidiogenous loci, 1–1.5 µm diam., slightly thickened and darkened. Conidia catenate, in simple or occasionally branched chains, ellipsoid-ovoid, cylindrical, 8–25 × 2–4(–5) µm, 0–1(–2)-septate, hyaline or subhyaline, thin-walled, smooth or almost so, ends obtuse to somewhat attenuated, hila 1–1.5 µm diam., slightly thickened and darkened.

Comments: Due to synnematous conidiomata with integrated, terminal as well as pleurogenous, cicatrized, hyaline or only pale conidiogenous cells, and hyaline or subhyaline conidia formed in chains, the new cercosporoid species on *Annona cherimolia* fits the concept of the hyphomycete genus *Phacellium* as circumscribed by Braun (1998). *Phacellium annonae-cherimoliae*, the first species of *Phacellium* on a host belonging to the *Annonaceae*, is morphologically close to *P. sessile* U. Braun, but differs in having longer and narrower, 0–1(–2)-septate, smooth conidia. *P. sessile*, on *Sanguisorba canadensis* in North America, possesses very similar synnemata with numerous pleurogenous conidiogenous cells, but the conidia are 10–16(–18) × 4–6(–8) µm, aseptate and verruculose (Braun 1998). The South American *P. paspali* (Syd.) U. Braun is a further similar species, also characterized by having slender, pigmented synnemata, often somewhat narrowed towards the apex, with little differentiated capitula and abundant pleurogenous conidiogenous cells, but the synnemata are pale reddish to pink and the conidia are aseptate. The type species of *Phacellium*, *P. inhonestum* Bonord. [= *P. alborosellum* (Desm.) U. Braun], is, except for the synnematous conidiomata, close to *Ramularia* Unger. Other species with distinctly pigmented synnemata and conidiophores are more cercosporoid, resembling phaeoramularia-like *Passalora* Fr. species, but differ in having pleurogenous, hyaline or subhyaline conidiogenous cells and colourless conidia. The taxonomy of this genus within the complex of cercosporoid *Mycosphaerella* anamorphs is still unclear. Cultures of the type species and molecular sequence analyses of various *Phacellium* species, including those with colorless and pigmented synnemata, are not yet available. Thus, we prefer to maintain *Phacellium* tentatively.

Pseudocercospora annonarum (Petr. & Cif.) U. Braun & Crous, **comb. nov.** FIG. 3

MYCOBANK MB 511859.

Bas.: *Isariopsis annonarum* [*'anonarum'*] Petr. & Cif., Ann. Mycol. 30: 235, 1932.

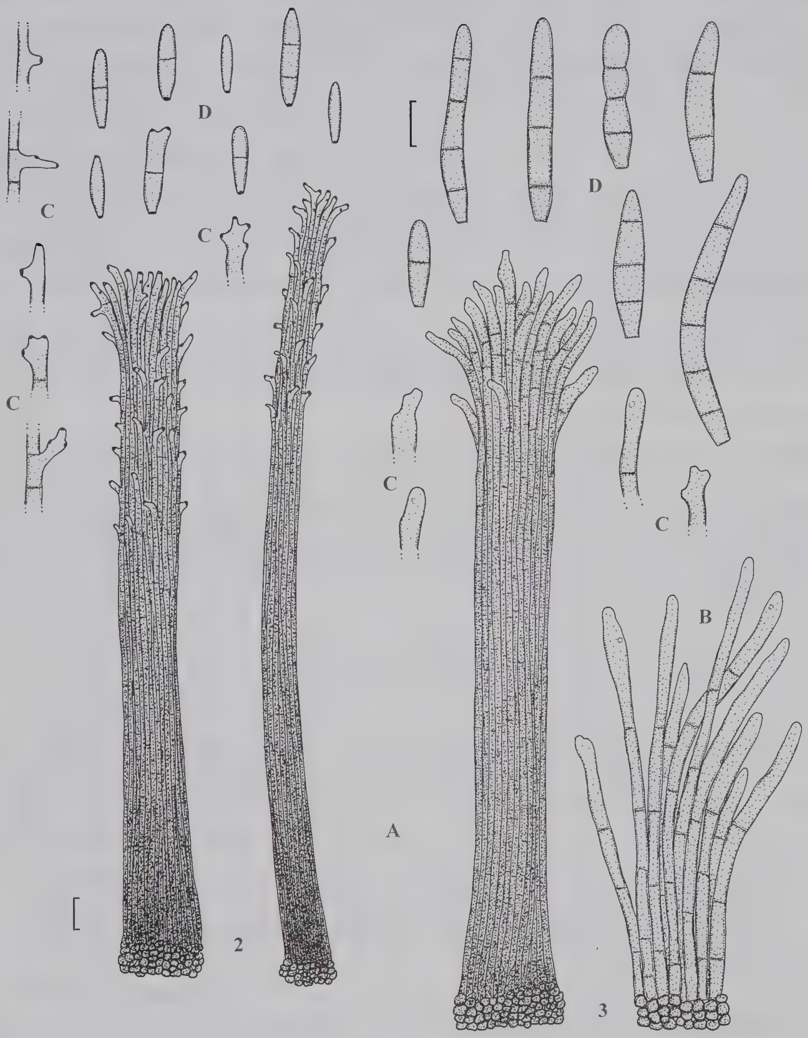
≡ *Phaeoisariopsis annonarum* (Petr. & Cif.) U. Braun, Nova Hedwigia 50: 511, 1990.

≡ *Passalora annonarum* (Petr. & Cif.) U. Braun & Crous, in Crous & Braun, *Mycosphaerella* and its anamorphs: 1. Names published in *Cercospora* and *Passalora*. CBS Biodiversity Series 1: 438, 2003.

MATERIAL EXAMINED: DOMINICAN REPUBLIC. Prov. Santiago, Santiago, Valle del Ciboa, on living leaves of *Annona squamosa* (*Annonaceae*), 22 Dec. 1930, Ekman (W, No. 10913), type of *I. annonarum*. VENEZUELA. Caracas, Los Chorros, on living leaves of *Annona squamosa*, Mar. 1939, Muller & Whetzl (CUP-VZ 2892), as *Cercospora annonaceae*.

LEAF SPOTS amphigenous, subcircular to angular-irregular, 1–10 mm diam., occasionally confluent, pale to dark brown, later grayish brown to dingy gray, on the lower leaf surface usually much paler, margin conspicuous, dark brown to blackish, narrow. CONIDIOMATA hypophyllous, synnematous, scattered, rather inconspicuous to punctiform, brown to dark brown. MYCELIUM internal. STROMATA immersed, 20–60 μm diam., brown. SYNNEMATA 80–250 × 20–50 μm, brown, composed of a mostly firm subcylindrical stipe of numerous, densely appressed parallel conidiophores and a more or less loose apical capitulum, often somewhat wider at the very base, occasionally with conidiophores in dense fascicles, i.e. not distinctly synnematous, individual conidiophores 40–250 × 2–5 μm, terminal cells (conidiogenous cells) up to 7 μm wide, olivaceous to medium brown, pluriseptate throughout, thin-walled, smooth. CONIDIOGENOUS CELLS integrated, terminal, rarely intercalary or pleurogenous, 10–25(–35) μm long; conidiogenous loci inconspicuous to subconspicuous by being subdenticulate or by having an unthickened, but slightly darkened-refractive ultimate rim (paracercospora-like), visible in front view as minute circle, 1–2 μm diam. CONIDIA solitary, obclavate-cylindrical, occasionally subclavate, short conidia sometimes ellipsoid-ovoid, straight to curved, (15–)25–70(–80) × (3.5–)4–8 (–9) μm, (0–)1–7(–10)-septate, occasionally constricted at the septa, pale to medium olivaceous or olivaceous-brown, thin-walled (ca. 0.5 μm), smooth, apex obtuse, base obconically truncate to somewhat convex, (1.5–)2–2.5(–3) μm wide, unthickened, not darkened, at most slightly refractive.

COMMENTS: During the course of a revision and reassessment of the genus *Phacellium* (= *Isariopsis* Fresen.), Braun (1990) reallocated cercosporoid species with pigmented, scolecoid conidia, including *Isariopsis annonarum*, to *Phaeoisariopsis* Ferraris. Later it turned out that the formation of synnematous conidiomata is of little taxonomic relevance at generic level in cercosporoid anamorphs. Furthermore, the genus *Phaeoisariopsis* proved to be heterogeneous, encompassing passalora-like species with conspicuous, thickened and darkened conidiogenous loci as well as pseudocercospora-like taxa with inconspicuous loci (Deighton 1990, Crous & Braun 2003).



Figs 2–3. 2. *Phacellium annonae-cherimoliae*. 3. *Pseudocercospora annonarum*. A. Synnemata. B. Conidiophores in a dense fascicle. C. Conidiogenous cells. D. Conidia (based on type material, except for fig. B of *P. annonarum* which is based on CUP-VZ 2892). Scale bars = 10 μm. U. Braun *del.*

Hence, most species of *Phaeoisariopsis* were reallocated to *Passalora* and *Pseudocercospora*, respectively. Due to subconspicuous conidiogenous loci (ultimate rim unthickened, but somewhat darkened-refractive, scars visible in front view as minute circles), Crous & Braun (2003) assigned *I. annonarum* to *Passalora*. Based on a molecular and morphological reassessment of *Phaeoisariopsis griseola* (Sacc.) Ferraris, the type species, Crous et al. (2006) reduced the genus *Phaeoisariopsis* to synonymy with *Pseudocercospora*. *P. griseola* is characterized by having conidiogenous loci ranging from being quite inconspicuous to subconspicuous by being unthickened, but slightly darkened-refractive, at least with regard to the ultimate rim. Since *P. griseola* clustered within a subclade formed by other *Pseudocercospora* species, it became clear that taxa with minutely thickened and slightly darkened conidiogenous loci have to be placed in *Pseudocercospora*. The recent examination of the rich collection of *I. annonarum* from Venezuela showed that this species has a similar morphological range of the conidiogenous loci as in *P. griseola*. Thus, *I. annonarum* is better placed in *Pseudocercospora*.

Key to cercosporoid hyphomycete species on hosts of the *Annonaceae*

Numerous cercosporoid hyphomycete species, including the taxa treated herein, have been described on host species belonging to the *Annonaceae*. The following key and brief discussions on some of the species listed have been prepared to render the differences between the taxa concerned palpable.

1 Conidiophores in distinct synnemata 2
1* Conidiophores mononematous, solitary or fasciculate 3

2 Synnemata composed of a firm stipe and a ± loose capitulum; conidiogenous cells usually integrated, terminal; conidiogenous loci inconspicuous or only ultimate rim slightly darkened-refractive (visible in front view as minute circle); conidia solitary, pigmented, (15–)25–70(–80) × (3.5–)4–8(–9) µm; on *Annona squamosa* .... *Pseudocercospora annonarum*
2* Synnemata composed of a firm stipe and a compact, little differentiated capitulum; conidiogenous cells frequently pleurogenous; conidiogenous loci minute, but conspicuous, thickened and darkened; conidia catenate, hyaline or subhyaline, 8–25 × 2–4(–5) µm, 0–1(–2)-septate; on *Annona cherimolia* .... *Phacellium annonae-cherimoliae*

3 Conidiogenous loci conspicuous, thickened and darkened 4
3* Conidiogenous loci inconspicuous, at most subconspicuous by being denticle-like, but neither thickened nor darkened 11

4 Superficial mycelium present; hyphae distinctly verruculose 5
4* Superficial mycelium smooth or lacking 6

5 Conidiophores solitary, arising from superficial hyphae, as well as fasciculate; on *Annona* spp., Brazil .... *Stenella annonaceae*
5* Conidiophores consistently solitary, arising from superficial hyphae; on *Polyalthia suberosa*, India .... *Stenella polyalthiae*

6 Conidiophores fasciculate, pigmented; conidia solitary, acicular when mature, pluriseptate, hyaline; on *Annona* spp. .... *Cercospora apii* s. lat.

6* Conidiophores fasciculate or solitary, pigmented; conidia not acicular, solitary and pigmented or catenate and ± hyaline (*Passalora*) 7

7 Conidia catenate 8

7* Conidia solitary 9

8 Conidiophores 120–200(–250) µm long; conidia 30–70 × 3–4 µm, 2–7-septate, subhyaline to pale brown; on *Isolona cauliflora*, Kenya ...... *Passalora isolonae*

8* Conidiophores 30–150 µm long; conidia 20–40(–65) × 2–4.5 µm, 0–3(–5)-septate, hyaline or subhyaline; on *Annona dioica* and *Xylopia grandiflora*, Brazil .... *Passalora xylopiae*

9(7) Conidiophores solitary and fasciculate, ca. 60–210 × 5.5–9 µm; conidia ca. 35–130 × 7–9 µm, 1–4-septate; on *Miliusa* sp., India .... *Passalora annonacearum*

9* Conidiophores much shorter and narrower, up to 80 × 6 µm 10

10 Conidiophores solitary, arising from superficial hyphae; conidia 14.5–50 µm long, up to 4-septate; on *Miliusa tomentosa*, India .... *Passalora miliusae*

10* Conidiophores fasciculate, emerging through stomata; conidia 25–80 µm long, 3–8-septate; on *Annona* spp., Brazil .... *Passalora annonigena*

11(3) Superficial mycelium present; conidiophores solitary as well as fasciculate, sometimes even in sporodochial conidiomata 12

11* Superfical mycelium lacking; conidiophores consistently in loose to dense, almost sporodochial fascicles 17

12 Conidia very broad, 20–80 × 4–12 µm, with 1–9 transverse and occasionally 1(–2) oblique or longitudinal septa; on *Asimina triloba*, North America .... *Pseudocercospora asiminae*

12* Conidia much narrower, up to 7 µm wide, only transversely septate 13

13 Conidiophores consistently solitary, arising from superficial hyphae, distinct fascicles lacking, 12–70 × 3.5–5 µm; conidia narrowly obclavate-cylindrical, 40–156 × 2.5–3.5 µm, 3–13-septate; on *Polyalthia suberosa*, India .... *Pseudocercospora polyalthiae*

13* Conidiophores solitary as well as fasciculate 14

14 Conidia very long and wide, 50–150 × 5–7 µm, densely pluriseptate (6–18), hila 2.5–3.5 µm wide; conidiophores usually fasciculate, occasionally solitary, arising from superficial hyphae; on *Annona* spp. and *Rollinia* sp., Asia, West Indies, Central to South America .... *Pseudocercospora annonae*

14* Conidia narrower, 1.5–6(–7) µm wide, up to 10-septate, hila narrower, 1–2.5 µm 15

15 Conidia 25–140 × 3–6(–7) µm, very pale, mostly subhyaline; on *Asimina* spp., North America .... *Pseudocercospora asiminae-pygmaeae*

15* Conidia narrower, 1.5–4 µm, subhyaline to pale brown; on *Annona* and *Rollinia* spp. 16

16 Superficial mycelium with solitary conidiophores abundant, fascicles of conidiophores variable, small and loose to rich and dense, occasionally in almost sporodochial conidiomata; apex of conidia obtuse in cylindrical conidia to subacute in obclavate conidia; on *Annona* spp. and *Rollinia mucosa*, Asia, West Indies, Central to South America .. *Pseudocercospora annonae-squamosae*

16* Mycelium internal and external, but conidiophores in dense fascicles, solitary conidiophores lacking; apex of conidia obtuse; on *Annona purpurea*, Brazil .... *Pseudocercospora xenoannonicola*

17(11) Conidiophores in sporodochial conidiomata; conidiogenous cells monoblastic, percurrent, with distinct annellations; conidia rough-walled 18

17* Conidiogenous cells monoblastic to usually polyblastic, sympodial, annellations lacking; conidia smooth or almost so 19

18 Conidiophores 30–50 µm long, verruculose; conidia 40–120 × 4.5–8 µm, obclavate-cylindrical; on *Annona senegalensis*, South Africa .... *Pseudocercospora oblecta*

18* Conidiophores shorter, 5–20(–30) µm long, smooth; conidia narrower, 20–220 × 3.5–5 µm, cylindrical-vermiform; on *Annona crassifolia*, Brazil .... *Pseudocercospora annonifolii*

19(17) Conidia broad, 5–8 µm; conidiophores in small, ± loose fascicles 20

19* Conidia narrower, 2–5 µm; conidiophores usually numerous, in ± dense, often sporodochial fascicles 21

20 Conidiophores fasciculate, very long, 60–220 µm; conidia obclavate, 50–110 µm long, base obconically truncate; on *Annona senegalensis* and *Annona* sp., Africa, Asia .... *Pseudocercospora scitula*

20* Conidiophores much shorter, up to 100 µm long, fasciculate, occasionally solitary, arising from superficial hyphae; conidia broadly acicular-obclavate, base truncate to slightly obconically truncate; on *Annona* spp. and *Rollinia* sp., Asia, West Indies, Central to South America .... *Pseudocercospora annonae*

21(19) Conidia subcylindrical-filiform to subacicular, 57.5–115 × 3.5–4.5 µm, hyaline; on *Miliusa* sp., India .... *Pseudocercospora annonacea*

21* Conidia obclavate-cylindrical, narrower, 2–3 µm wide, olivaceous to olivaceous-brown 22

22 Conidia (30–)50–80(–100) µm long; mycelium internal and external; on *Annona montana*, Brazil .... *Pseudocercospora xenoannonicola*

22* Conidia shorter, 30–65 µm long; mycelium consistently internal; on *Xylopia aethiopica*, Africa .... *Pseudocercospora aethiopicae*

Cercospora apii Fresen. s. lat. (sensu Crous & Braun 2003).

COMMENT: *C. apii* s. lat. (incl. *C. canescens* Ellis & G. Martin) has been recorded on *Annona* '*odorata*' (Crous & Braun 2003).

Passalora annonacearum [‘***anonacearum***’] A.N. Rai & Kamal,
Kavaka 14: 33, 1988 [‘1986’].

ILLUSTRATION: Rai & Kamal (1988: 34, Fig. 2).

On *Miliusa* sp., Asia, India.

Passalora annonigena U. Braun & F.O. Freire,
Cryptog. Mycol. 23: 297, 2003 [‘2002’].

ILLUSTRATION: Braun & Freire (2003: 298, Fig. 2).

On *Annona* sp., South America, Brazil.

Passalora isolonae (Siboe, P.M. Kirk & P.F. Cannon) U. Braun & Crous,
in Crous & Braun, *Mycosphaerella* and its anamorphs. 1. Names published in *Cercospora* and *Passalora*. CBS Biodiversity Series 1: 457, 2003.

≡ *Phaeoramularia isolonae* Siboe, P.M. Kirk & P.F. Cannon, in Siboe et al., Sydowia 52(2): 299, 2000.

ILLUSTRATION: Siboe et al. (2000: 300, Fig. 6).

On *Isolona cauliflora*, Africa, Kenya.

Passalora miliusae U. Braun & Crous,
in Crous & Braun, *Mycosphaerella* and its anamorphs. 1. Names published in *Cercospora* and *Passalora*. CBS Biodiversity Series 1: 460, 2003.

≡ *Mycovellosiella indica* P. Kumar & Kamal, Curr. Sci. 51: 846, 1982, non *Passalora indica* Kamal & P. Kumar, 1981.

ILLUSTRATION: Kumar & Kamal (1982: 846, Figs 1–2).

On *Miliusa tomentosa*, Asia, India.

Passalora xylopiae (Viégas & Chupp) U. Braun & Crous,
in Crous & Braun, *Mycosphaerella* and its anamorphs. 1. Names published in *Cercospora* and *Passalora*. CBS Biodiversity Series 1: 432, 2003.

≡ *Cercospora xylopiae* Viégas & Chupp, in Viégas, Bol. Brasil. Agron. 8: 58, 1945.

LITERATURE: Chupp (1954: 46).

On *Annona dioica* and *Xylopia grandiflora*, South America, Brazil.

Phacellium annonae-cherimoliae, see above.

Pseudocercospora aethiopicae Deighton, Mycol. Pap. 140: 13, 1976.

Illustration: Deighton (1976: 14, Fig. 3).

On *Xylopia aethiopica*, Africa, Sierra Leone.

Pseudocercospora annonacea (Kamal, Narayan & R.P. Verma) U. Braun, Nova Hedwigia 58(1–2): 209, 1994.

≡ *Cercoseptoria annonacea* [‘*anonacea*’] Kamal, Narayan & R.P. Verma, Indian Phytopathol. 39(3): 455, 1987 [‘1986’].

= *Pseudocercosporella miliusae* M.D. Mehrotra & R.K. Verma, Mycol. Res. 95: 1168, 1991.

LITERATURE: Braun (1995: 194).

ILLUSTRATION: Kamal et al. (1987: 455, Fig. 2).

On *Miliusa velutina*, Asia, India.

Pseudocercospora annonae U. Braun & Crous, in Braun et al., Feddes Repert. 113: 117, 2002.

≡ *Cercospora annonae* [‘*anonae*’] A.S. Mull. & Chupp, Arq. Inst. Biol. Veg. Rio de Janeiro 1: 214, 1935, nom. inval.

LITERATURE: Chupp (1954: 45), Crous & Braun (2003: 59).

ILLUSTRATION: Braun et al. (2002: 115, Fig. 5).

On *Annona cherimolia*, *A. muricata*, *A. reticulata*, *A. squamosa*, *Annona* sp., Asia, West Indies, Central to South America (Brazil, Cuba, Guatemala, India, Panama, Philippines, Venezuela).

Pseudocercospora annonae-squamosae U. Braun & R.F. Castañeda, in Castañeda & Braun, Cryptog. Bot. 1: 50, 1989. Fig. 4

= *Cercospora caracasensis* Chupp & A.S. Mull., Bol. Soc. Venez. Ci. Nat. 8: 39, 1942, nom. inval.

= *Pseudocercospora annonicola* Goh & W.H. Hsieh, in Hsieh & Goh, *Cercospora* and similar fungi from Taiwan: 22, 1990.

LITERATURE: Chupp (1954: 45), Vasudeva (1963: 67).

ILLUSTRATIONS: Vasudeva (1963: 68, Fig. 33), Castañeda & Braun (1989: 48, Fig. 19), Hsieh & Goh (1990: 22, Fig. 10).

MATERIAL EXAMINED: CUBA. Santiago de las Vegas, on living leaves of *Annona squamosa*, 29 Dec. 1987, R.F. Castañeda C87/376 (HAL 1650 F), holotype of *P. annonae-squamosae*. BRAZIL. State of Ceará, Paraipaba City, on living leaves of *Annona cherimolia* × *squamosa*, 19 May 2003, E. Cordoso (HAL 2219 F); State of Ceará, Pacajus County, on living leaves of *Annona muricata*, 19 Sep. 1999, F. Freire (HAL 2222 F); State of Pará, Amazonian Region, Belém City, on living leaves of *Annona pygmaea*, 30 Aug. 2003, L. Poltronieri (HAL 2220 F); State of Ceará, Pacajus County, on living leaves of *Annona squamosa*, 11 May 1999, F. Freire (HAL 2223 F); State of Ceará, Cascavel County, Preaoca District, on living leaves of *Annona* sp., 16 Mar. 2000, F. Freire (HAL 2224 F); State of Pará, Amazonian Region, Belém City, on living leaves of *Rollinia mucosa*, 28 Aug. 2003, L. Poltonieri (HAL 2221 F). VENEZUELA. Caracas, on living leaves of *Annona purpurea*, 1 Mar. 1938, A.S. Muller (CUP-VZ 2111), holotype of *C. caracasensis*.

On *Annona atemoya*, *A. cherimolia* × *squamosa*, *A. muricata*, *A. purpurea*, *A. pygmaea*, *A. reticulata*, *A. squamosa*, *Annona* sp., *Rollinia mucosa*, Asia, West Indies, central to South America (Brazil, Cuba, India, Japan, Panama, Taiwan, Venezuela).

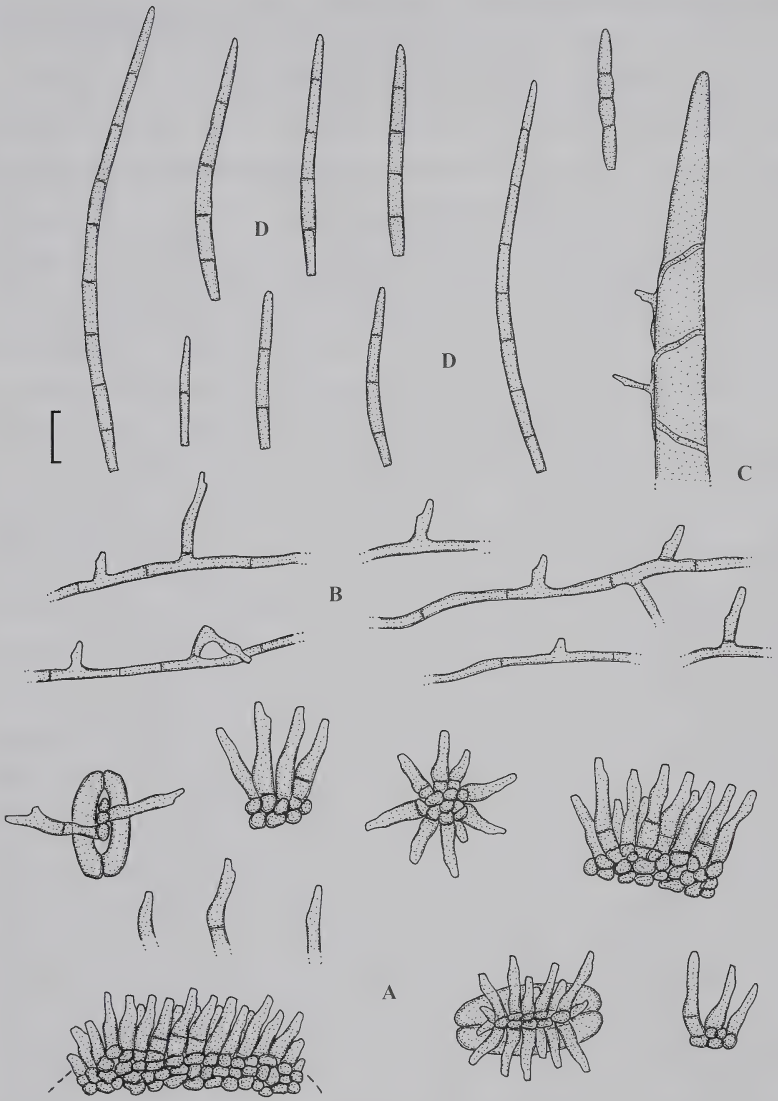


Fig. 4. *Pseudocercospora annonae-squamosae.* A. Conidiophore fascicles. B. Superficial hyphae with solitary conidiophores. C. Hyphae climbing a leaf hair. D. Conidia (A based CUP-VZ 2111, B–D based on type material. Scale bar = 10 μm. U. Braun *del.*

COMMENTS: With regard to the formation of solitary and fasciculate conidiophores, *P. annonae-squamosae* is rather polymorphous. Relatively large, dense, sometimes almost sporodochial fascicles of conidiophores with well-developed stromata, are usually epiphyllously formed, whereas on the lower leaf side the conidiophores are usually solitary arising from superficial hyphae, and only arranged in smaller fascicles with lacking or small stromata. The development of superficial hyphae with solitary conidiophores on the one hand and well-developed fascicles on the other hand is rather variable. Superficial mycelium may be sparsely developed in some collections, as for instance in the type material of *C. caracasensis*, and well-developed conidiophore fascicles may be lacking in other specimens, as in the holotype of this species. Therefore, the following redescription of this species based on a wider range of collections on various host species is necessary in order to demonstrate its variability: Leaf spots amphigenous, subcircular to angular-irregular, 1–30 mm diam., occasionally confluent, reddish brown, medium to dark or blackish brown, later often grayish brown to dingy gray, finally sometimes grayish white, often vein-limited, margin indefinite or with a darker marginal line. Caespituli amphigenous, on the upper side conspicuous, punctiform, scattered, dark brown to blackish, but soon turning grayish by abundant conidial formation, on the lower leaf surface subeffuse and less conspicuous, dingy grayish olivaceous to olivaceous-brown. Mycelium internal and external; superficial hyphae variable, ranging from almost lacking to well-developed, usually hypophyllous, emerging through stomata, occasionally climbing leaf hairs, branched, septate, 1–3.5 µm wide, thin-walled, pale olivaceous to olivaceous-brown, smooth. Stromata almost lacking to well-developed, above all on the upper side, 10–80 µm diam., substomatal to intraepidermal, olivaceous-brown. Conidiophores in small, loose to large and dense, almost sporodochial fascicles, arising from internal hyhae or stromata, emerging through stomata or erumpent, and solitary, arising from superficial hyphae, lateral, rarely terminal (on the upper side usually in well-developed, sometimes almost sporodochial fascicles, on the lower side in small, loose fascicles and solitary, arising from superficial hyphae), erect, straight, subcylindrical, conical to distinctly geniculate-sinuous, usually unbranched, 5–30(–45) × 2–4(–5) µm, 0–1(–2)-septate, subhyaline to pale olivaceous or olivaceous-brown, medium olivaceous-brown in mass, thin-walled, smooth. Conidiogenous cells integrated, terminal or conidiophores reduced to conidiogenous cells, 5–20 µm long; conidiogenous loci inconspicuous to subconspicuous by being truncate or subdenticulate, but always unthickened and not darkened. Conidia solitary, narrowly obclavate-cylindrical, (15–)20–75(–85) × (1.5–)2–4(–5) µm, (1–)2–6(–8)-septate, occasionally slightly constricted at the septa, subhyaline to pale olivaceous, thin-walled, smooth, apex obtuse, above all in cylindrical conidia, to subacute, above all in obclavate conidia, base short obconically truncate, 1–2 µm wide, hila unthickened, neither darkened nor refractive.

Pseudocercospora annonarum, see above.

Pseudocercospora annonifolii (Bat. & Peres) U. Braun & O.F. Freire, in Braun, Bibl. Lichenol. 86: 82, 2003.

≡ *Cercospora annonifolii* Bat. & Peres, Anais do XIII Congresso da Sociedad Botânica do Brasil: 374, 1964 ['1962'].

Illustration: Braun (2003: 93, Fig. 4).

On *Annona crassifolia*, South America, Brazil.

Pseudocercospora asiminae (Ellis & Morgan) U. Braun & Crous, **comb. nov.**

MycoBank, MB 511860.

Bas: *Phloeospora* ['*Phleospora*'] *asiminae* Ellis & Morgan, in Martin, J. Mycol. 3: 88, 1887.

≡ *Rhopaloconidium asiminae* (Ellis & Morgan) Petr., Sydowia 6: 301, 1952.

≡ *Miuraea asiminae* (Ellis & Morgan) Arx & Constant., in Arx, Proc. Kon. Ned. Akad. Wetensch., C 86: 39, 1983.

= *Cercospora asiminae* Ellis & Kellerm., J. Mycol. 3: 103, 1887.

≡ *Centrospora asiminae* (Ellis & Kellerm.) Deighton, Mycol. Pap. 124: 5, 1971.

≡ *Mycocentrospora asiminae* (Ellis & Kellerm.) Deighton, Taxon 21: 716, 1972.

Literature: Chupp (1954: 45), Braun (1995: 223), Crous & Braun (2003: 68).

Illustration: Braun (1995: 222, Fig. 211a).

On *Asimina parviflora*, '*A. obtusa*' and *A. triloba*, North America, USA.

Comments: Based on a re-examination of type material of *Phloeospora asiminae* and *Cercospora asiminae*, Braun (1995) confirmed that the two taxa are conspecific and, due to the occurrence of some conidia with oblique or longitudinal septa, followed Arx & Constantinescu (in Arx 1983) in placing this species in *Miuraea* Hara. The latter genus is insufficiently known and undoubtedly heterogeneous (Braun 1995). Cultures and molecular sequence analyses of *M. degenerans* (Syd. & P. Syd.) Hara, the type species, are not yet available. This species is characterized by having pigmented, thick-walled, dictyosporous conidia. *Miuraea persicae* (Sacc.) Hara is a colorless *Mycosphaerella* anamorph probably closely related to the genus *Pseudocercosporella* Deighton. The fungus on *Asimina* species is, however, better placed in *Pseudocercospora*. The conidiophores are formed singly, arising from superficial hyphae, as well as fasciculate, pigmented, with unthickened, neither darkened nor refractive conidiogenous loci. The conidia are only slightly thickened, transversely septate, only occasionally with 1(–2) oblique or longitudinal septa (Braun 1995). The formation of oblique or longitudinal septa in conidia of *Pseudocercospora* is unusual, but may occur, even in *P. vitis* (Lév.) Speg. (Deighton 1976), the type species, i.e. this feature does not exclude this cercosporoid *Asimina* species from the latter genus.

Pseudocercospora asiminae-pygmaeae U. Braun, A monograph of *Cercosporella*, *Ramularia* and allied genera (phytopathogenic hyphomycetes), Vol. 1: 223, 1995.

Illustration: Braun (1995: 222, Fig. 211b).

On *Asimina angustifolia*, *A. incana* and *A. pygmaea*, North America, USA.

Pseudocercospora oblecta (Syd.) Crous & U. Braun, **comb. nov.**

Mycobank MB 511861.

Bas.: *Cercospora oblecta* Syd., Ann. Mycol. 33: 235, 1935.

≡ *Stigmina oblecta* (Syd.) Crous & U. Braun, Mycotaxon 57: 285, 1996.

Literature: Chupp (1954: 45).

Illustration: Crous & Braun (1996: 286, Fig. 8).

On *Annona senegalensis*, South Africa.

Comments: On account of rather coarse conidiophores with percurrently proliferating conidiogenous cells, Crous & Braun (1996) assigned *C. oblecta* to the genus *Stigmina* Sacc. in the broad sense of Ellis (1971, 1976). The conidiogenous loci in this species are pseudocercospora-like, i.e. unthickened and non-pigmented. Braun (1993) introduced the genus *Cercostigmina* U. Braun for stigmina-like *Mycosphaerella* anamorphs with thin-walled, euseptate, scolecosporous conidia, which was later reduced to synonymy with *Pseudocercospora* based on a molecular and morphological reassessment (Crous & Braun 2003). *Scolecostigmina* U. Braun (Braun et al. 1999) was proposed for similar anamorphs with coarse, thick- and often rough-walled conidiophores formed in sporodochial conidiomata and relatively broad conidia, with slightly thickened, relatively dark conidia. The status of this genus is unclear. Cultures of the type species and molecular sequence analyses are not yet available. But most species assigned to this genus are probably *Mycosphaerella* anamorphs that should better be accommodated in *Pseudocercospora*. Crous et al. (2006) demonstrated that even *Stigmina platani* (Fuckel) Sacc., the type species of *Stigmina*, characterized by having phragmosporous, distoseptate conidia, represents a *Mycosphaerella* anamorph clustering in the *Pseudocercospora* clade. Braun & Crous (2006) proposed to conserve *Pseudocercospora* against *Stigmina* and *Phaeoisariopsis*. *Cercospora oblecta* is morphologically similar to *Pseudocercospora annonifolii*.

Pseudocercospora polyalthiae J.M. Yen, A.K. Kar & B.K. Das,
Mycotaxon 16(1): 43, 1982.

Illustration: Yen et al. (1982: 44, Fig. 4 E–G).

On *Polyalthia suberosa*, Asia, India.

Pseudocercospora xenoannonicola Crous & Bench.,
in Crous et al., Sydowia 52(2): 88, 2000.

Illustration: Crous et al. (2000: 87, Fig. 10).

On *Annona montana*, South America, Brazil.

Stenella annonaceae, see above.

***Stenella polyalthiae* [*'polylathiae'*]** S. Chaudhary, N. Sharma & Kamal, Indian Phytopathol. 55(1): 58, 2002.

Illustration: Chaudhary et al. (2002: 58, Fig. 2).

On *Polyalthia suberosa*, Asia, India.

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Novelties on Southern Brazilian *Parmeliaceae*

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Abstract — *Bulbothrix megapotamica*, *Myelochroa supraflava* and *Xanthoparmelia conglomerata* are described as new species. The new combination *Parmotrema aberrans* is made. *Rimelia luminosa* is synonymized under *Parmotrema diffractaicum*.

Key words — *Bulbothrix subcoronata*, *Myelochroa aurulenta*, *Xanthoparmelia punctulata*

The *Parmeliaceae* is the most significant family of lichenized fungi in the Brazilian biomes (Marcelli 1998). The same is true for Rio Grande do Sul State, where 169 species in 17 genera were already reported (Spielmann 2006).

During a survey of the *Parmeliaceae* in the area of Fazenda da Estrela (Canêz 2005) several new species were found and three of them are formally described here. In addition, a new combination and a new synonym are proposed.

Fazenda da Estrela, with an area of 287 km^2, is located in Vacaria Municipality, in the northern highlands of the southern Brazilian state of Rio Grande do Sul. *Araucaria angustifolia* (Bertol.) Kuntze forests and grasslands are the predominant vegetation types.

The material and methods used here are described in Canêz & Marcelli (2007).

New species

Bulbothrix megapotamica Canêz & Marcelli, **sp. nov.** Fig. 1
MycoBank MB 511099

Diagnosis: *Sicut Bulbothrix subcoronata, sed sporis majoribus differt.*

Holotype–Brazil, Rio Grande do Sul State, Municipality of Vacaria, Fazenda da Estrela, 28°04'58.9"S, 50°56'48.9"W, 850 m alt., open field, on a shrub branch, leg. L.S. Canêz & A.A. Spielmann 146, 23-II-2003 (SP).

Thallus whitish gray, sublaciniate, up to 5.0 cm wide; sublaciniae irregularly branched, 0.4–1.5 mm wide, adnate, contiguous, apices slightly truncate, often recurved, almost perpendicular to the substrate, margin smooth, surface continuous, smooth, slightly shiny. LACINULAE and MACULAE absent. CILIA black, simple, 0.15–0.35 × 0.05 mm, bulbate, bulbs 0.05–0.20 mm wide, abundant, contiguous on the axils, with interciliary spaces equivalent to one bulb on the lateral margins and almost contiguous at the apices. PUSTULAE, SORALIA and ISIDIA absent. MEDULLA white throughout. LOWER SURFACE black, shiny, slightly rugose; MARGINAL zone concolorous or dark brown, shiny, 0.45–0.75 mm wide, poorly delimited, smooth; RHIZINAE black, present to the margin, simple, base not bulbate, 0.20–0.75 × 0.05 mm, very dense and evenly distributed. APOTHECIA slightly concave, 0.5–3.0 mm diam., adnate, laminal, margin irregularly crenate and coronate, with almost equally sized bulbae in the axils, disc brown, slightly concave, imperforate, amphithecium smooth; ASCOSPORES ellipsoid, 13.7–17.5 × (7.5–) 8.7–10.0 (–11.0) µm, epispore 1.2 µm thick. PYCNIDIA laminal and submarginal, ostiole black; CONIDIA bifusiform, 4.0–6.0 × 1.0 µm.

SPOT TESTS– cortex K+ yellow, UV–; medulla K+ yellow → reddish orange, C–, KC–, P+ yellow, UV–.

TLC– atranorin (traces, cortex) and norstictic acid (medulla).

COMMENTS– *Bulbothrix megapotamica* is distinctive by producing coronate apothecia with large ascospores (13.7–17.5 µm), abundant cilia, the black lower surface, and the medullary norstictic acid, associated to the absence of vegetative propagules.

This new species is part of a group of adnate sublaciniate species with globose cilia and norstictic acid containing, common in Southeast Brazil. It is similar to *B. subcoronata* (Müll. Arg.) Hale that has smaller ascospores (5–7.5 µm), and *B. viatica* Spielmann & Marcelli with ascospores 12–17.5 µm but a brown undersurface (Spielmann & Marcelli 2008).

Müller Argoviensis reported the ascospores of *B. subcoronata* as 5 µm long, the smallest size found in the genus. Several authors apparently considered that a mistake, as Jungbluth (2006) reported sizes from 8 to 15 µm based on reports by Eliasaro (2001), Fleig (1985) and Marcelli (1993) for material identified as *B. subcoronata* from several places in natural areas of southern and southeastern Brazil. However, a recent examination of the lectotype (G!) of *B. subcoronata* revealed that the spores are really 5–7.5 µm long (Benatti, pers. comm.).

Furthermore, influenced by Hale's classical monograph on *Bulbothrix*, all these researchers have named as *B. subcoronata* those specimens with a completely brown underside. However, the lectotype analysis revealed that the real underside color is of an undeniable bright black, with only a narrow brown marginal zone.

The concept of *B. subcoronata* is currently under revision by M.N. Benatti, and we believe that at least two or three species with different ascospore size and underside color may be involved.

Bulbothrix sensibilis (J.Steiner & Zahlbr.) Hale, a species with black underside, has cilia with short apices and salazinic acid in the medulla. All other similar species have smaller ascospores and/or a brownish underside.

The holotype of *B. megapotamica* has slightly downturned cilia almost perpendicular to the substrate; however, it was not possible to decide if this is a character of taxonomical value.

The specific epithet (Greek: mega + potamos = big river), several times used by G.O. Malme for species of the same region, refers to Rio Grande do Sul State, whose name means Big South River.

Myelochroa supraflava Canêz & Marcelli, **sp. nov.** FIG. 2

MYCOBANK MB 511098

DIAGNOSIS: *Affinis Myelochroae aurulentae, sed medulla supra lutea et infra alba differt.*

HOLOTYPE–Brazil, Rio Grande do Sul State, Municipality of Vacaria, Fazenda da Estrela, riverside vegetation, 28°04'49.2"S, 50°56'36.9"W, 850 m alt., saxicolous (basalt), near the stream, leg. L.S. Canêz & A.A. Spielmann 1377, 10-I-2004 (SP; isotypes in HAS and NY).

THALLUS whitish gray, sublaciniate, up to 9 cm in diameter; LACINIAE subdichotomous, 0.5–3.0 mm wide, adnate, contiguous to slightly overlapping, apices brownish, mostly truncate, margin smooth, upper surface continuous, smooth but slightly irregularly pitted, shiny; LACINULAE absent; MACULAE weak, punctiform, laminal; CILIA black, simple to rarely furcate, 0.10–0.25 × 0.05 mm, irregularly dispersed throughout at the margin but contiguous in the axillae. PUSTULAE small, generally 0.1–0.3 mm, mostly subapical, sometimes developed also on elevated parts of the lamina, circular to slightly elongated, bursting apically since young to form coarse soredia and often leaving the yellow medulla exposed, chiefly aggregated into capitate masses 1.0–2.5 mm diam. SORALIA capitate, originating from the pustulae; SOREDIA granular and subgranular. ISIDIA absent. MEDULLA bicolored, the upper 3/4 pigmented yellow and the lower 1/4 portion white. LOWER SURFACE black, shiny, rugose; MARGINAL ZONE dark brown, shiny, 0.3–1.5 mm, poorly delimited, densely papillate; RHIZINAE black, simple to less frequently irregularly branched, 0.25–0.90 mm long, dense, almost reaching the margins, often with grouped to agglutinated, especially in the thallus center. APOTHECIA absent. PYCNIDIA absent.

SPOT TESTS– cortex K+ yellow, UV– or + pale yellow on the tips of some lobes; medulla K+ burnt yellow, C+ strongly yellow, KC–, P–, UV–.

TLC– atranorin (cortex), zeorin, secalonic acid A and leucotylic acid (medulla).

> Paratypes: Brazil, Rio Grande do Sul State, Municipality of Boqueirão do Leão, open place, 29°18'13.7"S, 52°26'51.7"W, 500 m alt., saxicolous at the margin of a stream, partially open, leg. A.A. Spielmann & M.A. Sulzbacher 760, 31-I-2004 (SP); idem, Minas Gerais State, Municipality of Ouro Preto, northeastern outskirts of city Ouro Preto, 20°23'S, 43°29-30'W, 1250 m alt., on hardpan, leg. G. Eiten 6932, 28-IX-1965 (SP).

Comments– *Myelochroa supraflava* has oval axils that give it a laced aspect, resembling some growth patterns of *Hypotrachyna livida* (Taylor) Hale. The principal characteristic is its medullary coloration, which is almost completely yellow, but with a thin white layer adjacent to the lower cortex. The specific epithet refers to this.

The closest species is *M. aurulenta* (Tuck.) Elix & Hale, which has the same chemistry and is sorediate. Compared to *M. supraflava*, it has a darker and grayish green thallus, overlapping lobes, a distinctly maculate surface, some pruinose lobe apices and a chiefly white medulla, with a yellow or orange color present only below or around the soralia (Hale 1976b, Elix 1994, Divakar & Upreti 2005). According to Hale (1976b), *M. aurulenta* has sublinear to subirregular or rounded, 2–4 mm wide lobes, simple to barely forked or squarrose rhizinae, and distinct, cracked areas that expose the medulla. *Myelochroa supraflava* also has these areas; however, it is yellow throughout the upper medulla.

Myelochroa supraflava also resembles the Southeast Asian *M. denegans* (Nyl.) Elix & Hale, which differs in having a reddish orange pigment in the lower part of medulla and pustalae in part entire (Elix 1994, Divakar & Upreti 2005).

Three records of *M. aurulenta* are published for Brazil (Hale 1976b, Marcelli 1993, Spielmann 2005). The revision of this material demonstrated that the specimens discussed by Hale and Spielmann are *M. supraflava*, and that Marcelli's specimen is a tiny lichen, possibly a new species of *Parmelinopsis* with yellow medulla. Apparently, *M. aurulenta* is not yet known from Brazil.

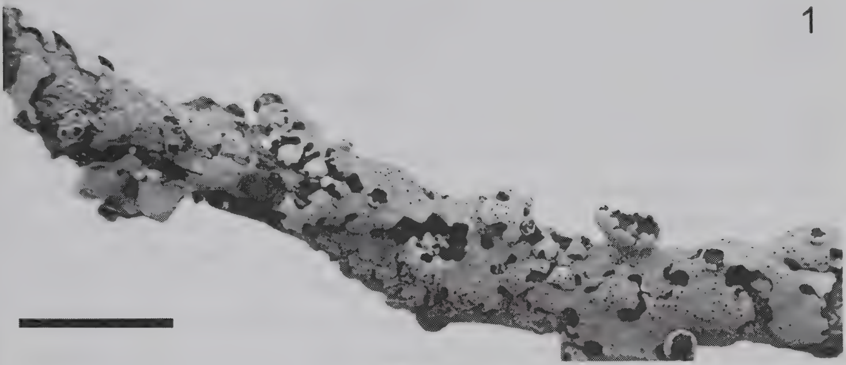
Xanthoparmelia conglomerata Canêz & Marcelli, **sp. nov.** Fig. 3

MycoBank MB 511100

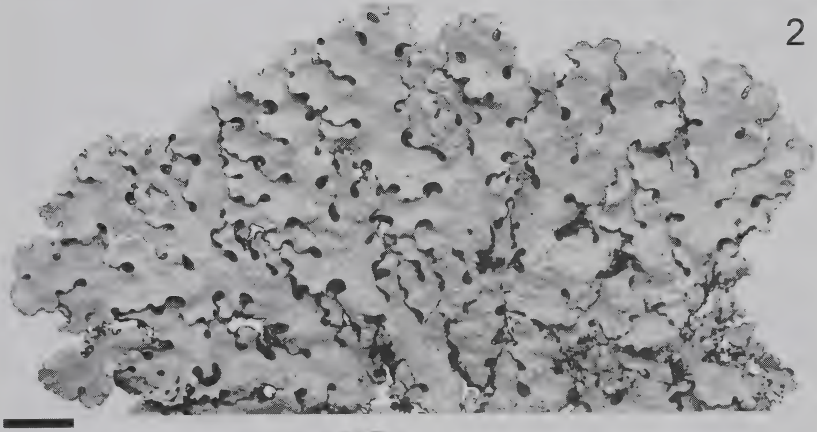
> Diagnosis: *Species thallo ut in Xanthoparmelia punctulata sed ab hac specie superficie inferiore nigra, isidiis globularibus deinde agglomeratis et acidum salazinicum continenti differt.*
>
> Holotype–Brazil, Rio Grande do Sul state, Municipality of Vacaria, Fazenda da Estrela, field, 28°02'44.6"S, 51°02'01.7"W, 860 m alt., on basaltic rock in a sunny place at the Frade River margin, leg. L.S. Canêz & A.A. Spielmann 692a, 11-I-2004 (SP; isotype in B).

Thallus greenish yellow, laciniate, 8.0–13.0 cm wide; laciniae subdichotomically or irregularly branched, 0.7–3.0 mm wide, separate to laterally imbricate, apices round to truncate, darkened; margins smooth; upper surface

1



2



3

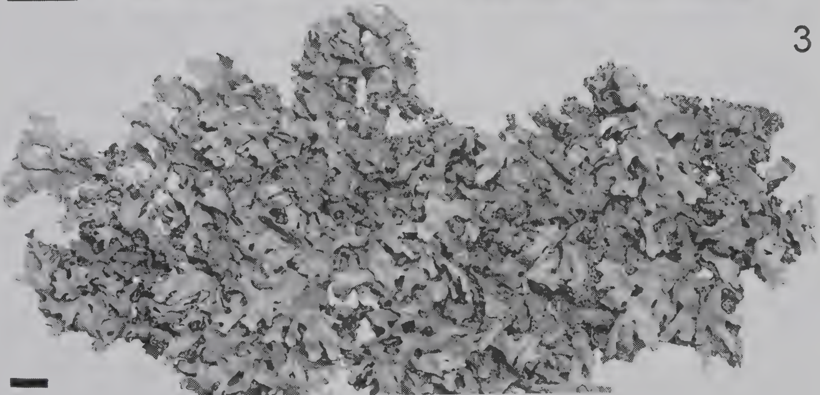


Fig. 1. *Bulbothrix megapotamica* (part of the holotype).
Fig. 2. *Myelochroa supraflava* (part of the holotype).
Fig. 3. *Xanthoparmelia conglomerata* (part of the holotype).
Bars = 5 mm.

continuous, rarely cracked in the central region, mostly smooth, shiny on the younger parts. LACINULAE, MACULAE, PUSTULAE and SORALIA absent. ISIDIA concolorous with the thallus, sometimes with brownish apices, mostly globose when young, then proliferating into large, capitate, sometimes coralloid, aggregates, 0.10–0.35 × 0.10–0.25 mm, erect, firm, eciliate at apices, laminal, rarely marginal. MEDULLA white, pigments absent. LOWER SURFACE black to dark brown, opaque, smooth; MARGINAL ZONE dark brown, shiny, 2.0–5.0(–7.0) mm wide, margin poorly delimited, smooth to slightly rugose; RHIZINAE black or concolorous with the margin, simple, 0.25–0.75 × 0.05–0.15 mm, unevenly distributed. APOTHECIA concave to almost plane, 0.75–1.50 mm in diameter, adnate, laminal, margins smooth to crenate, amphithecium smooth or barely isidiate, disc dark brown, imperforate; ASCOSPORES absent. PYCNIDIA laminal and submarginal, ostiole black; CONIDIA bifusiform, 5.0–7.5 × 1.0 µm.

SPOT TESTS– cortex K–, UV–; medulla K+ yellow → red, C–, KC–, P+ yellow, UV– or + pale yellow.

TLC– usnic acid (cortex), salazinic acid and traces of consalazinic acid (medulla).

PARATYPE—Brazil. Rio Grande do Sul State, Municipality of Vacaria, Fazenda da Estrela, field, 28°02'44.6"S, 51°02'01.7"W, 860 m alt., on basalt in sunny area at the Frade River margin, leg. L.S. Canêz & A.A. Spielmann 692b, 11-I-2004 (SP).

COMMENTS– *Xanthoparmelia conglomerata* is characterized by the aggregates of globular isidia, the production of salazinic acid (K+ yellow → red) and the black undersurface.

The species is easily recognized by its globose isidia that proliferate into large aggregates, which have a typical popcorn-like aspect (the reason for the name). Sometimes the younger isidia may look like granular soredia; however, an accurate examination reveals that they are truly granular isidia, that are completely corticate.

Xanthoparmelia tinctina (Maheu & A. Gillet) Hale, also with black undersuface and medullary salazinic acid, has different barrel-shaped to irregularly inflated isidia and a lobate thallus; in addition, their isidia do not form agglomerates and produces additionally norstictic acid (Hale 1990).

Xanthoparmelia antleriformis (Elix) Elix & J.Johnst. differs by its dark brown lower surface, its ramified, coralloid to antleriform isidia, and the presence of traces of norstictic acid together with salazinic and consalazinic acid. (Nash et al. 1995). *Xanthoparmelia punctulata* (Gyeln.) Hale produces salazinic and consalazinic acids in the medulla and has globose isidia; however, they are erumpent and form scurfy masses (Hale 1990). *Xanthoparmelia glomerulata* Krog & Swinscow has a brown lower surface and obconical isidia that degrade to corticated granules, and produce the stictic acid complex (Krog & Swinscow 1987).

New combination

Parmotrema aberrans (Vain.) Canêz & Marcelli, **comb. nov.**

MycoBank MB 511103

Basionym: *Parmelia xanthina* f. *aberrans* Vain., Acta Societatis pro Fauna et Flora Fennica 7(1): 37. 1890.

Type—Brazil, Minas Gerais State, Sitio [nowadays Antônio Carlos Municipality], leg. E.A. Vainio s.n., Lichenes brasiliensis exsiccati 664 (TUR-V 02758, holotype).

Comments–*Parmotrema aberrans* is characterized by a greenish yellow (usnic acid in the cortex) thallus, continuous cilia along the margins, cylindrical, ciliate isidia, and by producing gyrophoric acid in the medulla (C+ and KC+ rose).

Parmotrema xanthinum (Müll. Arg.) Hale also has cortical usnic acid and cylindrical, ciliate isidia, but does not produce gyrophoric acid (medulla C–, KC–) (Hale 1965, Nash & Elix 2002).

In his classical monograph, Hale (1965) mentioned *Parmelia xanthina* (Müll. Arg.) Vain. as having no medullary reactions, and placed *Parmelia* (= *Parmotrema*) *madagascariacea* (Hue) Abbayes (medulla C– and KC+ rose) under it as a synonym, distinguishing *Parmelia aberrans* (Vain.) Abbayes by its positive medullary reactions.

In order to understand the chemistry and nomenclature of the *P. xanthina* complex, Almeda & Dey (1973) made chromatography and agreed with Hale (1965) in naming *P. xanthina* the group without medullary reactions. They also discovered that the C–, KC+ rose collections in fact produced gyrophoric acid and had a subtle C+ rose reaction that could be easily overlooked. For this reason, they considered '*Parmelia aberrans* Hale' a synonym of *Parmelia madagascariacea*, the oldest valid combination.

Some years later, Krog & Swinscow (1981) made chromatography of the *Parmelia madagascariacea* holotype and mentioned the presence of an "acid aff. gyrophoric" (gyrophoric complex) different from gyrophoric acid in the holotype of *P. aberrans*. However, they considered both *P. aberrans* and Parmelia *madagascariacea* as synonyms of *P. xanthina*, not attributing any taxonomic value to the presence of gyrophoric acid.

Parmotrema aberrans was reported for Rio Grande do Sul State by Fleig (1990), from the Esmeralda Municipality. Years later, she (Fleig 1997) considered the species as synonym of *P. xanthinum*, and credited the combination *Parmotrema aberrans* to Hale (mentioning Hale 1965). However, Hale (1974) recognized the genus *Parmotrema* only about 10 years later and never made this combination.

Recently, Nash & Elix (2002) recognized and cited the species as '*Parmotrema aberrans* (Vain.) Abbayes' for the Sonoran Desert, but Abbayes made the combination *Parmelia aberrans* and never attributed the taxon to the genus *Parmotrema* (Abbayes 1959, according to Hale 1965).

Specimens of *Parmotrema aberrans* cited as *P. xanthinum* are also known from the mountains of São Paulo and Minas Gerais States in southeastern Brazil (Ribeiro 1998).

Recently, Canêz (2005) and Jungbluth (2006) recognized *Parmotrema aberrans*, from Rio Grande do Sul *Araucaria* forests and São Paulo State cerrado vegetation, respectively, but did not publish a valid combination.

As a matter of fact, there is no reliable report of the real *P. xanthinum* from Brazil, perhaps not even from South America.

New synonym

Parmotrema diffractaicum (Essl.) Hale, Phytologia 28(4): 335. 1974.

Basionym: *Parmelia diffractaica* Essl., Bryologist 75(1): 80. 1972.

Synonym–*Rimelia luminosa* Marcelli, Mitteilungen aus dem Institut für Allgemeine Botanik Hamburg 30-31: 152. 2002. [Holotype: Brasil, Minas Gerais, municipio de Catas Altas, Serra do Caraça, Parque Natural do Caraça, trilha para Cascatona, sobre tronco de árvore na mata úmida, 1330 m alt., 11-IX-1997, col. Marcelli & Ribeiro 32020 (SP !, holotype; B, isotype)].

Comments — *Parmotrema diffractaicum* is characterized by soralia and diffractaic acid associated with lichexanthone in the medulla (UV+ yellow orange-colored).

Morphologically, it is somewhat similar to *Parmotrema spinibarbe* (Kurok.) Hale ex DePriest & B.W. Hale, which also has medullary lichexanthone but produces additionally salazinic acid and its soralia is frequently submarginal, subapical or laminal.

Rimelia luminosa in the original description by Marcelli & Ribeiro (2002) was stated to differ in forming soralia and producing lichexanthone associated with α-collatolic acid in the medulla. However, chromatography of the holotype demonstrated medullary diffractaic acid instead, and its morphology is the same as described for *P. diffractaicum*. Consequently, we consider both as synonyms.

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New species of *Parmotrema* containing protocetraric or stictic acids from the coast of São Paulo State, southeastern Brazil

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Abstract — During a survey of *Parmeliaceae* species in natural ecosystems and urbanized coastal areas of southeastern Brazil, three new *Parmotrema* species were discovered: *P. eliasaroanum,* containing stictic acid, and *P. graniticum* and *P. milanezii,* containing protocetraric acid.

Key words — *Parmotrema perlatum, Parmotrema dilatatum, Parmotrema gardneri, Parmotrema lobulatum*

Introduction

The genus *Parmotrema* A. Massal. is characterized by lobes with broad rotund apices and naked lower margins, the absence of pseudocyphellae, the frequent occurrence of marginal cilia, simple rhizines, and thick-walled, ellipsoid ascospores (Brodo et al. 2001, Nash & Elix 2004). More than three hundred species are known world-wide (Nash & Elix 2004), 93 of which occur in Brazil (Marcelli 2004).

Two new species containing protocetraric acid and one containing stictic acid are described here. These species were discovered by the authors during research on the broad-lobed species of *Parmeliaceae* at the coast in São Paulo State, Brazil (Benatti 2005), for the most situated between the municipalities of Ubatuba (23°02´S, 45°04´W) and Itanhaém (24°11´S, 46°47´W). This region includes urbanized areas, rocky shores, as well as mangrove and restinga forests as the predominant vegetation types.

While *Parmotrema graniticum* is strictly saxicolous on rocky shores, the other species are corticolous in coastal mangrove and restinga forests. *Parmotrema eliasaroanum* lacks vegetative propagules whereas *P. graniticum* and *P. milanezii* are sorediate.

Although we have included sufficient specific information about the new taxa, more detailed morphological and chemical comparisons with other somewhat similar species can be found in Benatti (2005).

Materials and methods

Specimens were distinguished by morphological characters using standard stereoscopic and light microscopes. Anatomical sections, including those of apothecia and pycnidia, were made with a razor blade by hand. The chemical constituents were checked by spot tests with potassium hydroxide (K), sodium hypochlorite (C) and *para*-phenylenediamine (P), and also examined under UV light (360 nm). Chemical constituents were identified by thin-layer chromatography (TLC) using solvent C (Bungartz 2001), high performance liquid chromatography (HPLC) (Elix et al. 2003) and comparison with authentic samples.

Since we have encountered problems dealing with the many morphological terms present in the literature, we specify here that in our concept lacinules represent adventitious, ribbon-like secondary outgrowths from the primary lobes margins. Lobules are similar, but short and rounded.

The diagnosis refers exclusively to holotype characters and the English descriptions and comments to all the material studied.

The species

Parmotrema eliasaroanum Benatti, Marcelli & Elix, **sp. nov.** **Fig. 1**

MycoBank MB 511426

Diagnosis: *Species cum thallo simili Parmotrematis lobulati sed thallus magis adpressus et planus, lobis majoribus et subrotundatis; lacinulis marginalibus planis et ciliatis, non lobos apicales formantibus; lacinulae magis regulares, non lobulis secundariis; margine inferiori plerumque eburneo et conidia plerumque minoribus differt. Atranorinam, chloroatranorinam, acidum sticticum, acidum consticticum, acidum peristicticum, acidum cryptosticticum et acidum methylsticticum continens.*

Holotype–Brazil, São Paulo State, Municipality of Cananéia, Cardoso Island, restinga wood of Vila Marujá, 25°14′S, 48°01′W, 1 m alt., tree branch at the low wood behind the dunes, leg. M.P.Marcelli 1757, 20-X-1981 (SP; isotype in B).

Thallus up to 15 cm in diameter, subcoriaceous, ramulicolous, grayish green but becoming darker in the herbarium, lobed to sublobed; lobes irregularly branched, (2.0–)3.0–6.0 mm wide, contiguous to ± imbricate, becoming crowded in part when lacinulate, adnate to loosely adnate, lacinules ascending;

APICES ±flat unless lacinulate, subrotund to irregular; MARGIN smooth or subcrenate to irregularly dissected, ±flat, weakly undulate in part, entire to incised, lacinulate, ciliate. UPPER SURFACE continuous then weakly and irregularly cracked, smooth; MACULAE absent; LACINULES present; SORALIA, PUSTULES and ISIDIA absent; LACINULES short to ± elongate, evenly dispersed at the apices and along the margins of lobes, occasionally becoming crowded, usually more abundant in older parts, simple to anisotomic or irregularly dichotomous, ± flat, 0.4–5.6 × 0.2–1.2 mm, truncate to subtruncate, ciliate, not admixed with adventitious lobules, underside cream colored or occasionally variegated; CILIA black, simple, 0.2–1.5(–2.3) × ca. 0.05 mm, frequent along the margins. MEDULLA white, pigments absent. LOWER SURFACE black, shiny, smooth to subrugose, unevenly papillate, erhizinate in parts not in contact with the substrate; MARGIN shiny to opaque, usually cream or variegated, rarely pale brown in a few elacinulate distal lobes, smooth to subrugose, 1.0–5.5 mm wide, naked; RHIZINES black, simple, 0.1–1.3 × ca. 0.05 mm, absent, sparse or frequent, more common in parts in contact with the substrate, grouped. APOTHECIA submarginal to subterminal, common, concave, becoming distorted and involute with age, 0.8–6.0 mm wide, stipitate, margins crenate to denticulate-lacinulate, eciliate, amphithecia and stipe smooth; DISC brown, epruinose, imperforate; ASCOSPORES ellipsoid, 22.5–29 × 12.5–15 μm, epispore 3–4 μm wide. PYCNIDIA submarginal, common, abundant on lacinules, with black ostioles; CONIDIA bacilliform to short filiform, 4–8 × ca. 1 μm.

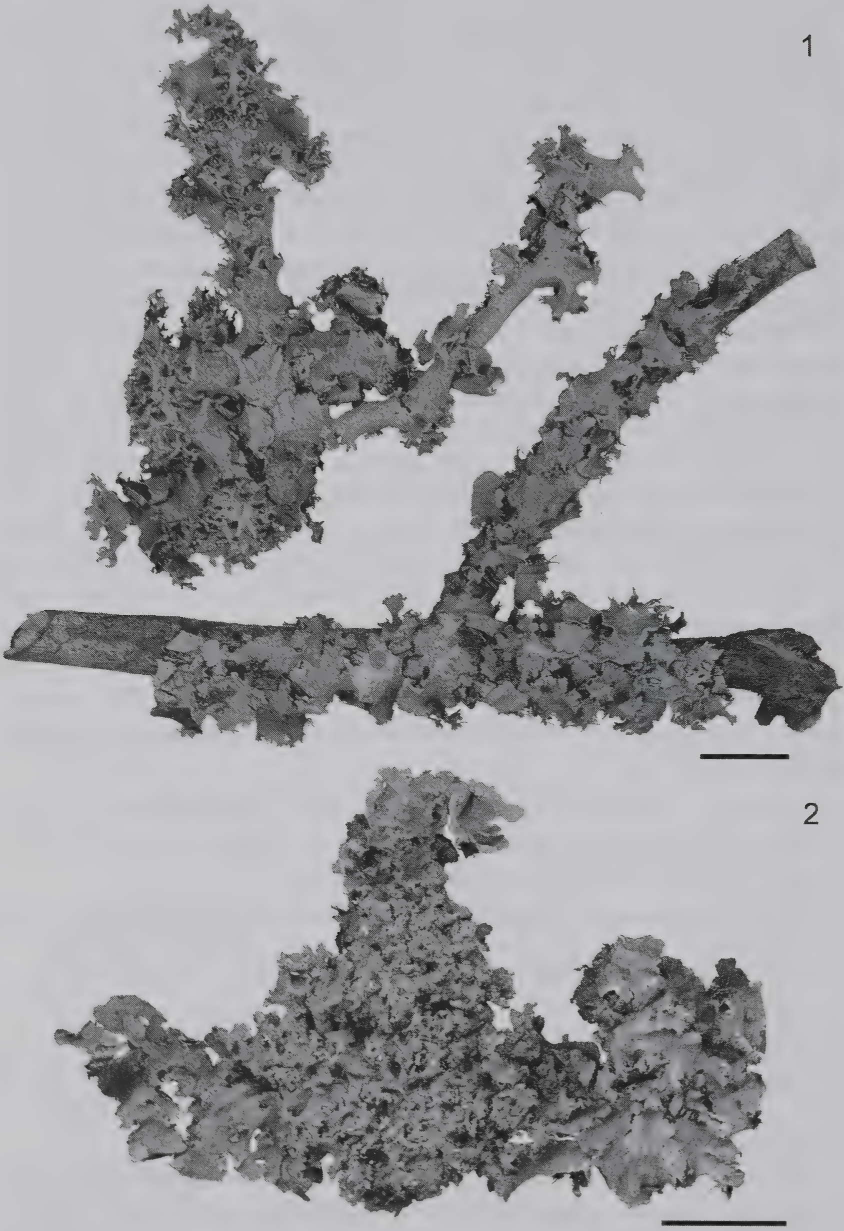
SPOT TESTS: upper cortex K+ yellow, UV–; medulla K+ yellow, C–, KC–, P+ orange, UV–.

TLC/HPLC: cortical atranorin (minor) and chloroatranorin (minor); medullary stictic acid (major), constictic acid (submajor), peristictic acid (trace) cryptostictic acid (minor) and methyl stictic acid (minor).

PARATYPE—Brazil, São Paulo State, Municipality of Iguape, Barra do Ribeira, between Suamirim "River" and the ocean, restinga wood at the mangrove´s edge, 24°38´S, 47°22´W, 1 m alt., thin branch of small tree, leg. M.P.Marcelli & O.Yano 6857, 18-07-1989 (SP).

COMMENTS–*Parmotrema eliasaroanum* is one of the few lacinulate species containing the stictic acid chemosyndrome and resembles *P. lobulatum* Marcelli & Hale (Fig. 2). However, these species differ in morphology and in some of their medullary substances.

Parmotrema eliasaroanum is characterized by the adnate thallus with ascending lacinulate lobes, the ciliate margins, dichotomous or irregularly-branched, flat, marginal non reproductive lacinules, the absence of soredia and isidia, an almost entirely cream coloured lower margin (possibly white when freshly collected), grouped rhizines and the presence of the stictic complex in



Figures 1-2. 1. Holotype (above) and isotype (below) of *P. eliasaroanum* (a single specimen).
2. Isotype of *P. lobulatum* (SP).
Bar = 1 cm.

the medulla. The apothecia are denticulate-lacinulate and eciliate, with smooth amphithecia.

When initial specimens of *P. eliasaroanum* were examined they were considered to be *P. lobulatum*, since the latter has marginal lacinules and stictic acid as the major medullary substance. However, after studying an isotype (SP!) and a topotype of this species, consistent differences were observed between the two species. *Parmotrema lobulatum* is a smaller lichen with a more loosely adnate, ascending thallus, with narrower (1.0–3.0 mm vs. 3.0–6.0 mm wide) and often more crowded lobes. In addition, *P. lobulatum* develops plane, more irregularly shaped and branched, eciliate lacinules that eventually become subcanaliculate as well as small, dense, procumbent lobules along the margins of the lobes and lacinules.

Parmotrema lobulatum also differs from *P. eliasaroanum* in having very narrow, brown colored lower margins [even of the lacinulate lobes], its lower cortex has more scattered rhizines, and the conidia are longer (7–9 μm vs. 4–8 μm).

The two specimens of *P. eliasaroanum* contain stictic, constictic, peristictic, cryptostictic and methyl stictic acids, whereas the two specimens of *P. lobulatum* contain stictic, constictic, menegazziaic, cryptostictic, peristictic, substictic, and hypostictic acids.

Other regularly lacinulate species, such as *P. zicoi* Marcelli & C.H. Ribeiro and *P. merrillii* (Vain.) Hale, differs in lobe width, lacinule size and shape, the colour of the lower margins, the presence of cilia, ascospore and conidia size and by containing protocetraric acid.

This species is named in honor of the Brazilian lichenologist Dr. Sionara Eliasaro, from the Universidade Federal do Paraná, who has made significant contributions in establishing and developing taxonomic lichenology in Brazil.

Parmotrema graniticum Benatti, Marcelli & Elix, **sp. nov.** **Fig. 3**

MycoBank MB 511904

Diagnosis: *Species cum thallo simili Parmotrematis mordenii sed thallus magis coriaceus, cortex superior atranorinam et acidum usnicum continens et medulla acidum protocetraricum, acidum conprotocetraricum, acidum virensicum, acidum subvirensicum, et acidum convirensicum continens, sed sine atranorina medullari.*

Holotype–Brazil, São Paulo State, Municipality of São Sebastião, Centro de Biologia Marinha da USP (CEBIMAR), Ponta do Baleeiro, southward rocky shore, 23°48´S, 45°37'W, 15 m alt., granitic rock, leg. M.P. Marcelli 2216, 19-III-1988 (SP; isotype in NY).

Thallus up to 10 cm in diameter, subcoriaceous, saxicolous, greenish gray becoming darker in the herbarium, lobate to sublobate; lobes 1.5–5.0(–7.0) mm wide, irregularly branched, contiguous to ± imbricate, tightly adnate; apices ±flat, subrotund; margin smooth to crenate or occasionally irregular in older parts, becoming more sinuous when sorediate, incised, flat to ±ascending (mainly when sorediate), partially involute, occasionally folded and subcanaliculate at the axils, ±undulate, unevenly sublacinulate, eciliate. UPPER SURFACE continuous but becoming irregularly cracked with age, smooth to subrugose, MACULAE absent, ADVENTICEOUS LACINULES common, very short and irregularly distributed along the lobes margins, simple, furcate or irregular, flat, 0.2–1.8(–3.0) × 0.2–0.9 mm, truncate, underside concolourous with the lower margin, occasionally intermixed with small adventitious irregular lobules, eciliate; SORALIA mainly marginal and linear, sometimes also at the apices of the lacinules, occasionally coalescing and becoming ±irregular, sometimes subcapitate and subpustular when (rarely) submarginal or laminal, SOREDIA granular to subgranular, not agglutinated. PUSTULES and ISIDIA absent. MEDULLA white, pigments absent. LOWER SURFACE black, shiny, smooth to subrugose, weakly veined in part, MARGIN shiny, reddish brown or rarely black, smooth, weakly veined, 0.5–4.0 mm wide, naked; RHIZINES black, simple, 0.1–0.7 × 0.05–0.1 mm, frequent, occasionally becoming agglutinated, grouped. APOTHECIA laminal to submarginal, rare, concave, 0.3–2.6 mm wide, sessile, margins smooth at first then sorediate, eciliate, amphithecia subrugose to sorediate, stipe smooth to subrugose; DISC brown, epruinose, imperforate; ASCOSPORES ellipsoid, 7.5–12.5 × 4.–6.5 µm, epispore ca. 1 µm thick. PYCNIDIA rare, submarginal, with black ostioles; CONIDIA weakly sublageniform, (4–)5–6.5 × ca. 1 µm.

SPOT TESTS: upper cortex K+ yellow, UV–; medulla K– or + weakly yellowish, C–, KC+ rose (→light orange), P+ orange, UV–.

TLC/HPLC: cortical atranorin (minor) and usnic acid (minor); medullary protocetraric acid (major), conprotocetraric acid (trace), virensic acid (trace), subvirensic acid (trace), and convirensic (minor).

PARATYPES— Brazil, São Paulo State, Municipality of São Sebastião, Centro de Biologia Marinha da USP, Ponta do Baleeiro, southward rocky shore, 23°48´S, 45°37W, 15 m alt., granitic rock, leg. M.P. Marcelli 2215 (S), 2222 (H), 2228 (SP), 2236 (B), 2246 (SP), 19-III-1988 (SP).

COMMENTS–*Parmotrema graniticum* is a saxicolous species morphologically similar to *P. mordenii* (Hale) Hale in the flat habit and common subpustular soredia, but with a very different chemistry.

In addition to the chemistry, *P. graniticum* is characterized by its ±flat thallus, the eciliate margins, irregular linear or subcapitate soralia appearing at the apices of short marginal lacinules, grouped rhizines and weakly sublageniform conidia. Unlike many other *Parmotrema* species with sorediate margins, the lower distal portions of *P. graniticum* are almost always brown (rarely black), usually with a reddish tone, even on sublacinulate and/or sorediate lobes.

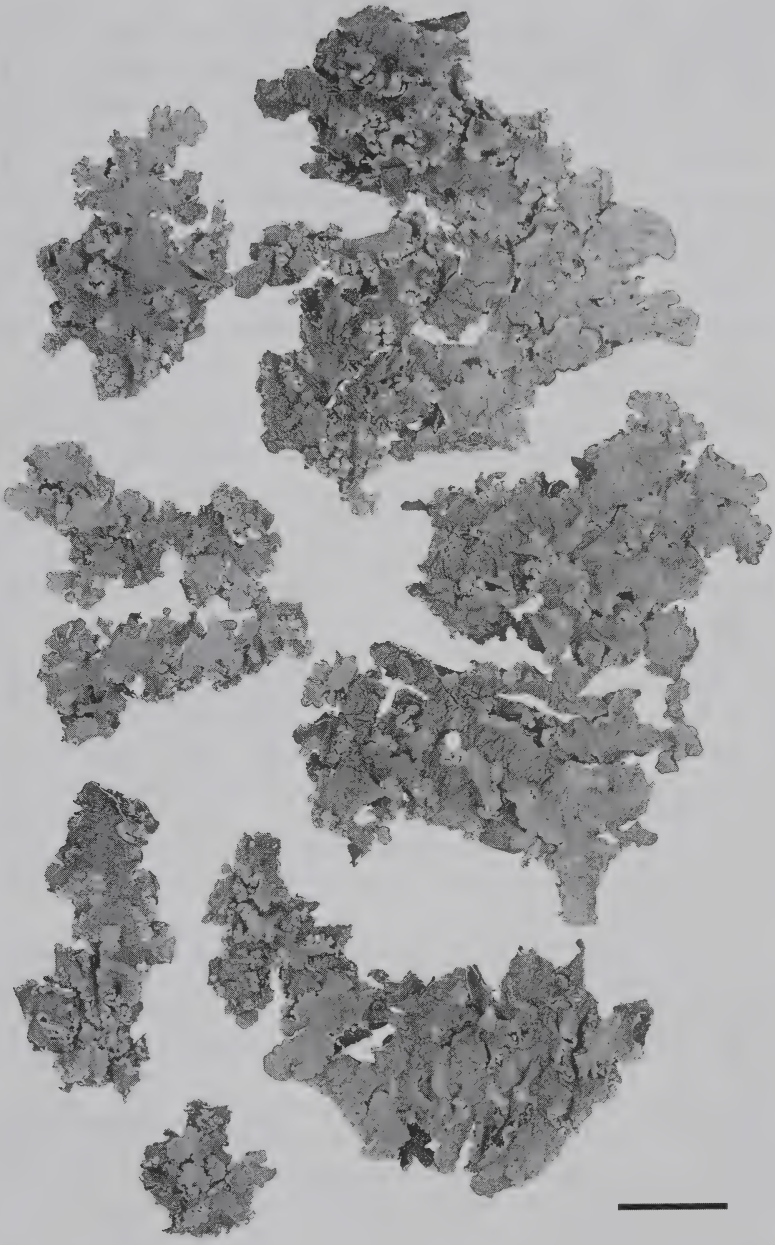


Figure 3. The fragment constituents of the type of *P. graniticum* before the isotype making (a single specimen). Bar = 1 cm.

Although morphologically similar to *P. mordenii* and some saxicolous specimens of *P. praesorediosum* (Ntl.) Hale, *P. graniticum* differs in having a more coriaceous thallus, in the cortical and medullary chemistry, and in the smaller, sub-bacilliform conidia, which have almost imperceptible dilations when compared to those of species with pronounced, sublageniform conidia.

Whereas *P. graniticum* contains cortical usnic acid and atranorin and the protocetraric acid chemosyndrome in the medulla, *P. praesorediosum* (which may also be corticolous), contains cortical atranorin and protopraesorediosic acid, praesorediosic acid and unknown fatty acids in the medulla. Furthermore, *P. praesorediosum* has a more delicate thallus with ascending lobe margins and develops chiefly farinose soredia and subcontinuous to labriform marginal soralia.

Parmotrema pardi (Krog & Swinscow) Krog & Swinscow, so far known only from East Africa (Krog & Swinscow 1981, 1983; Swinscow & Krog 1988), is the only other saxicolous species with sorediate lobes and medullary protocetraric acid, but has larger (0.8–2.0 cm wide), generally entire or subcrenate rather than sublacinulate lobes, sparse rhizines, imperforate apothecia that became perforate at maturity, filiform 10–14 µm conidia, only atranorin present at the upper cortex and fumarprotocetraric acid as well as protocetraric acid in the medulla.

Parmotrema gardneri (C.W.Dodge) Sérus. (Dodge 1959, Krog & Swinscow 1981, Swinscow & Krog 1988) is a further coriaceous, marginally sorediate, eciliate *Parmotrema* species which contains medullary protocetraric acid. However, it is a corticolous species with wider lobes (8.0–20.0 mm vs. 1.5–7.0 mm wide), occasionally develops short cilia and has larger ascospores than those of *P. graniticum* (16–26 × 8–14 µm vs. 7.5–12.5 × 4–6.5 Mm). Further, the upper cortex of *P. gardneri* contains only atranorin and chloroatranorin. [NB. medullary protocetraric, subvirensic, virensic, convirensic and conprotocetraric acid are present in *P. gardneri*].

Further similar sorediate species containing the protocetraric chemosyndrome include, *P. dilatatum* (Vain.) Hale, *P. schindleri* Hale, *P. fractum* (Hale) Hale, *P. ravum* (Krog & Swinscow) Sérus., and *P. dominicanum* (Vain.) Hale. However, these species exhibit significant differences as shown in Table 1.

In the specimens studied, we observed that many young apothecia had darkened discs without asci. The weak K+ yellowish medullary reaction observed in parts of some specimens is believed to be due the presence of small amounts of atranorin in the medulla adjacent to the upper cortex.

The specific epithet refers to the substrate on which the species commonly grows.

Table 1. Comparison of species of the *Parmotrema dilatatum* group according to several authors*

SPECIES	HABIT	MARGINAL CILIA (MM)	LOBE WIDTH (MM)	SORALIA	ASCOSPORES (µM)	CONIDIA (µM)	CORTICAL CHEMISTRY	MEDULLARY ACIDS
P. graniticum	saxicolous	absent	1.5–5 (–7)	marginal linear (laminal subcapitate)	7.5–12.5×4–6.5	weakly sublageniform (4–) 5–6.5	atranorin usnic acid	protocetraric virensic
P. pardi (f, g)	saxicolous	absent	8–15 (–20)	marginal linear to subcapitate laminal	10–13×6–8	filiform 10–14	atranorin	protoceraric fumarprotocetraric
P. schindleri (d)	saxicolous	sparse, axilary	4–7	marginal, mainly on lacinules	unknown	unknown	atranorin	protocetraric giroforic
P. dominicanum (b, c)	corticolous or saxicolous	absent	5–12	marginal irregular, distinctly yellowish	16–18×5-7	unknown	atranorin usnic acid	protocetraric
P. fractum (c)	unknown	marginal, simple,1–2	Up to 20	laminal, pustular	30–38×16–20	unknown	atranorin usnic acid	protocetraric
P. ravum (f, g)	corticolous	absent	5–10 (–1.5)	marginal linear to subcapitate	18–22×8–10	filiform 10–12	atranorin usnic acid	protocetraric fatty
P. gardneri (e, f, g, h, i)	corticolous	absent	(4–) 8–15 (h) 10–20 (e)	marginal capitate, confluent	16–20×10–12 (e) 24–26×12–14 (h)	sublageniform 6–7.5 (h)	atranorin	protocetraric virensic
P. dilatatum (a, c, f, g, h, i, j, k, l)	corticolous or (i) saxicolous	absent to (c, j) scarse	5–10 15–30	marginal linear to capitate on lacinules	18–22×8–10 (c) 20–28×8–10 (a)	lageniform to sublageniform 5–7 (k, l)	atranorin usnic acid	protocetraric echinocarpic
P. milanezii	corticolous	marginal, ramified, 1–2.5 (–4)	3.5–11 (–20)	marginal capitate on lacinules, confluent	unknown	unknown	atranorin usnic acid	protocetraric echinocarpic

*a-Vainio 1890; b-Vainio 1896; c-Hale 1965; d-Hale 1986; e-Dodge 1959; f-Krog & Swinscow 1981; g-Swinscow & Krog 1988; h-Louwhoff & Elix 1999; i-Elix 1994; j-Fleig 1997;k-Eliasaro 2001; l-Donha 2005).

Parmotrema milanezii Marcelli, Benatti & Elix, **sp. nov.** **Fig. 4**

MycoBank MB 511905

Diagnosis: *Species cum thallo simili Parmotrematis dilatati sed thallo membranaceo, margine abundanter ciliato, ciliis plerumque ramosis etiam in soraliis formantibus differt; atranorinam, chloroatranorinam, acidum usnicum, acidum protocetraricum, acidum echinocarpicum, acidum conechinocarpicum, acidum convirensicum, acidum subvirensicum et acidum secalonicum A continens.*

Holotype–Brazil, São Paulo State, Municipality of Itanhaém, Jardim Grandesp, km 116 of Padre Manoel da Nóbrega Highway, between the highway and the foot of the Serra do Mar mountains, high restinga forest ca. 2 km from the highway, at the edge of track following the direction of the Serra do Mar, 24°12´S, 46°53´W, 16 m alt., small tree trunk, leg. M.P.Marcelli & J.Vieira Filho 9193, 30-01-1982 (SP; isotype in S).

Thallus up to 20.5 cm diam., submembranaceous to membranaceous, corticolous, greenish gray becoming pale brown in the herbarium, lobate; lobes 3.5–11.0(–20.0) mm wide, irregularly branched, younger lobes contiguous to subimbricate, becoming crowded at maturity, adnate to weakly ascending when sorediate, adnate to loosely adnate; apices ±flat, rotund to subrotund; margin initially smooth becoming subcrenate, flat near the apices but becoming subundulate in part and weakly ascending in older parts, becoming involute or revolute when sorediate, entire to incised, ±sublacinulate, ciliate; cilia black, simple to dichotomous or irregularly branched, 0.1–2.5(–3.8) × 0.05–0.1 mm, usually abundant along the margins even amidst the soralia, absent at the lobes apices.. Upper surface smooth to subrugose in part, distal lobes continuous, becoming irregularly cracked within; maculae, pustules and isidia absent, lacinules and soredia present; lacinules short, irregular on the margins and at the apices of older lobes, simple to rarely furcate, flat, 0.4–2.2 × 0.3–0.8 mm, truncate, underside generally white, rarely variegated or black, less frequently concolorous with the lower margin, rarely intermixed with small, irregular, adventitious lobules; soralia marginal on small lacinules, irregularly linear to subcapitate, often coalescing laterally and becoming ±dense and irregular, ±raised, soredia farinose to subgranular, coarse in part. Medulla white, pigments absent. Lower surface black, shiny, smooth to rugose, veined to very rarely subpapillate, lacking rhizines in part, margin shiny, brown, smooth or rarely rugose, weakly veined to papillate, 1.5–6.5 mm wide, naked, becoming cream coloured or variegated under sorediate lobes; rhizines black, simple to ±furcate, 0.2–0.8(–1.9) × 0.05–0.1 mm, absent to frequent in part, grouped. Apothecia submarginal, very rare, concave, 2.3 mm diam., substipitate, margin smooth, sorediate, eciliate, amphithecia and stipe smooth; disc brown, epruinose, imperforate; ascospores not found; pycnidia very rare, submarginal, with black ostioles; conidia not seen.

Spot tests: upper cortex K+ yellow, UV–; medulla K+ yellow, C–, KC+ rose, P+ orange, UV–.

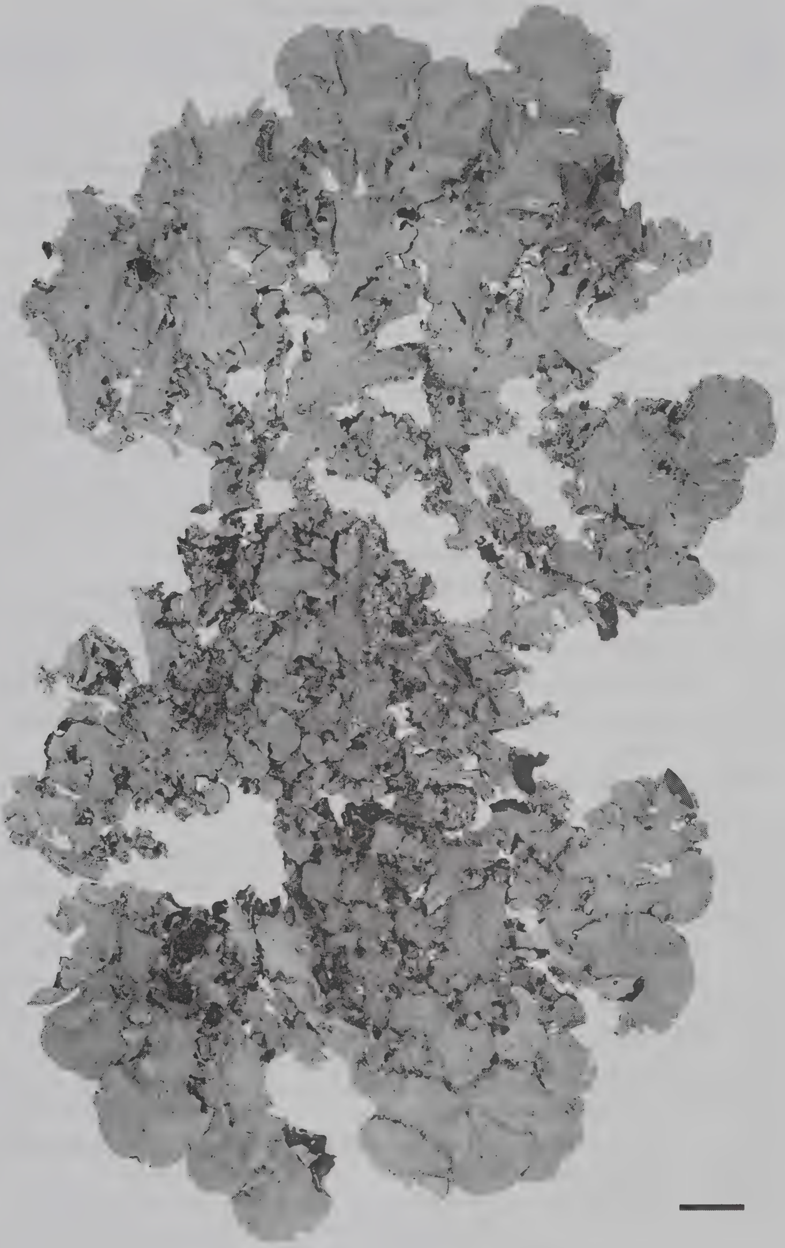


Figure 4. Type of *P. milanezii* before the making of the isotype (upper portion). Bar = 1 cm.

TLC/HPLC: cortical atranorin (minor), chloroatranorin (minor) and usnic acid (trace); medullary protocetraric acid (major), echinocarpic acid (minor), subvirensic acid (trace), convirensic acid (trace), conechinocarpic acid (±trace) and secalonic A acid (±trace).

> PARATYPES— Brazil, São Paulo State, Municipality of Ilha Comprida, southern part of the island, at the edge of the road near the raft to Cananéia, low restinga wood, 25°01´S, 47°54´W, 6 m alt., on tree branch inside the wood, leg. L.S.Canêz, A.A.Spielmann, M.N.Benatti & M.P.Marcelli 1291, 02-IV-2004 (NY); idem, bush branch inside the wood, leg. L.S.Canêz, A.A.Spielmann, M.N.Benatti & M.P.Marcelli 1312, 02-IV-2004 (SP).

COMMENTS– *Parmotrema milanezii* is distinguished by its flat, adnate, membranaceous thallus, the lower cortex with sparse groups of rhizines, the sorediate margins with small lacinules, and the dense, branched cilia within the soralia, each cilium (usually) fixed to an individual soredium grain, which can be readily detached by removing the cilium. This feature distinguished it from all other sorediate *Parmotrema* species, where the cilia are usually not present at the margin where it begins to open or erode to form soredia. This species contains the protocetraric and echinocarpic acid chemosyndromes in the medulla, thus resembling the chemistry of *P. dilatatum*.

Like *P. milanezii, P. dilatatum* has sorediate margins with small lacinules but lacks the very dense, commonly branched cilia arising from individual grains of soredia. Further, *P. dilatatum* is normally described as eciliate (e.g. Vainio 1890, Swinscow & Krog 1988, Louwhoff & Elix 1999, Elix 1994), or cited as producing very sparse simple, short marginal cilia, which are generally restricted to the lobes axils (see Hale 1965, Fleig 1997).

Parmotrema perlatum (Huds.) M.Choisy, another K+ yellow ciliate and sorediate species, usually has simple cilia, which do not occur in the sorediate parts and it contains the stictic acid chemosyndrome in the medulla. Further, *P. perlatum* has narrower lobes, shorter cilia (rarely more than 1.5 mm long), and a more densely rhizinate lower surface with scattered rhizines.

The overall morphology of *P. schindleri* is similar to *P. milanezii*, but it differs in having short, sparse cilia in the axils, sparse marginal lacinules and in containing protocetraric and gyrophoric acids in the medulla (Hale 1986). *P. schindlerii* was recorded as a strictly saxicolous species.

This new species is named in honor of the Brazilian mycologist Dr. Adauto Ivo Milanez, a distinguished mycologist and member of the Brazilian scientific community who has expended considerable effort in encouraging lichenological research at the Instituto de Botânica.

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New records of three freshwater ascomycetes from an urban lagoon of Tabasco, Mexico

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Abstract — A survey of lignicolous freshwater ascomycetes was carried out in Las Ilusiones Lagoon located in the metropolitan area of Villahermosa City, State of Tabasco, Mexico. *Aniptodera inflatiascigera, Ascosacculus aquaticus* and *A. heteroguttulatus* are recorded for the first time from Mexico. This study is an important contribution to the knowledge of the worldwide distribution of these three species from tropical freshwater ecosystems.

Key words — *Halosphaeriales*, lentic habitat, *Sordariales*, submerged wood panels, taxonomy

Introduction

The number of fungal species described worldwide is around 80,060 (Kirk et al. 2001). Of these, only about 500 species are freshwater meiosporic euascomycetes (Tsui & Hyde 2003, Vijaykrishna et al. 2006, Shearer et al. 2007). Little is known about the biodiversity of this group of ascomycetes from tropical eco-regions (Vijaykrishna & Hyde 2006) and particularly Mexico. The only knowledge of ascomycetes from a lentic freshwater environment is from a study by González & Chavarria (2005) of freshwater ascomycetes from a temperate urban ecosystem situated in the metropolitan zone of Mexico City.

During the past two years a biodiversity project to study lignicolous freshwater ascomycetes of the State of Tabasco was undertaken because it is located in one of the highest precipitation regions of Mexico, which results in an elevated diversity of natural and urban lentic habitats. Las Ilusiones Lagoon is located in the residential section of Villahermosa City, capital of the State of Tabasco. This lotic environment has vital importance as a water reservoir for the city and it is a popular recreational area. In this study, we identify and illustrate three freshwater ascomycetes recorded from Mexico for the first time.

Materials and methods

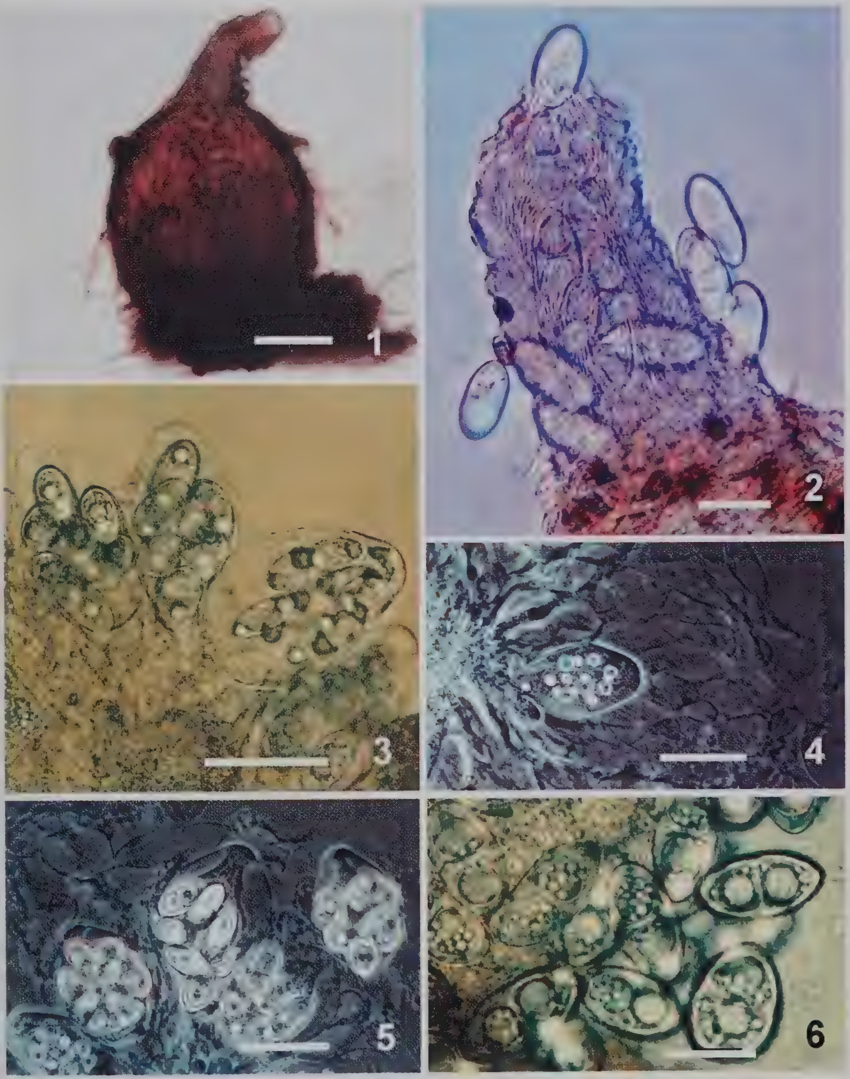
Wood panels submerged for three months in the Las Ilusiones Lagoon (17°59'22", 18°01'22" N and 92°55'20", 92°56'40" W, cover surface 198.4 ha), located in the urban zone of Villahermosa City, Tabasco State, México (Rodríguez 2002). The phosphorous and nitrogen elevated values registered at Las Ilusiones Lagoon suggest eutrophication, based on boundary values of the trophic classification system (OECD 1982). The exposed panels were retrieved, placed in Zip-lock® plastic bags, transported to the laboratory in a cooler containing ice and processed within 6 h. Collected material was washed in tap water and placed in transparent plastic boxes containing moist paper towels (Jones 1971). Samples were incubated at laboratory conditions (25–30 C) under natural daylight. Wood panels were examined at one month for the presence of fungal fruiting structures. For morphological examination, squash mounts of ascomata in sterile water were prepared on glass slides, and ascomata, paraphyses, asci and ascospores were measured and photographed using an Olympus BX50 light/interference/phase contrast microscope. Dried specimens on wood panels and permanent microscope slides, prepared according to the double cover glass method (Volkmann-Kohlmeyer & Kohlmeyer 1996), have been deposited in the fungal collection of Herbario Nacional (MEXU) of the Institute of Biology, Universidad Nacional Autónoma de México.

Taxonomy

Aniptodera inflatiascigera K. M. Tsui, K.D. Hyde & Hodgkiss,
Sydowia 49: 188 (1997). **Figs. 1–6**

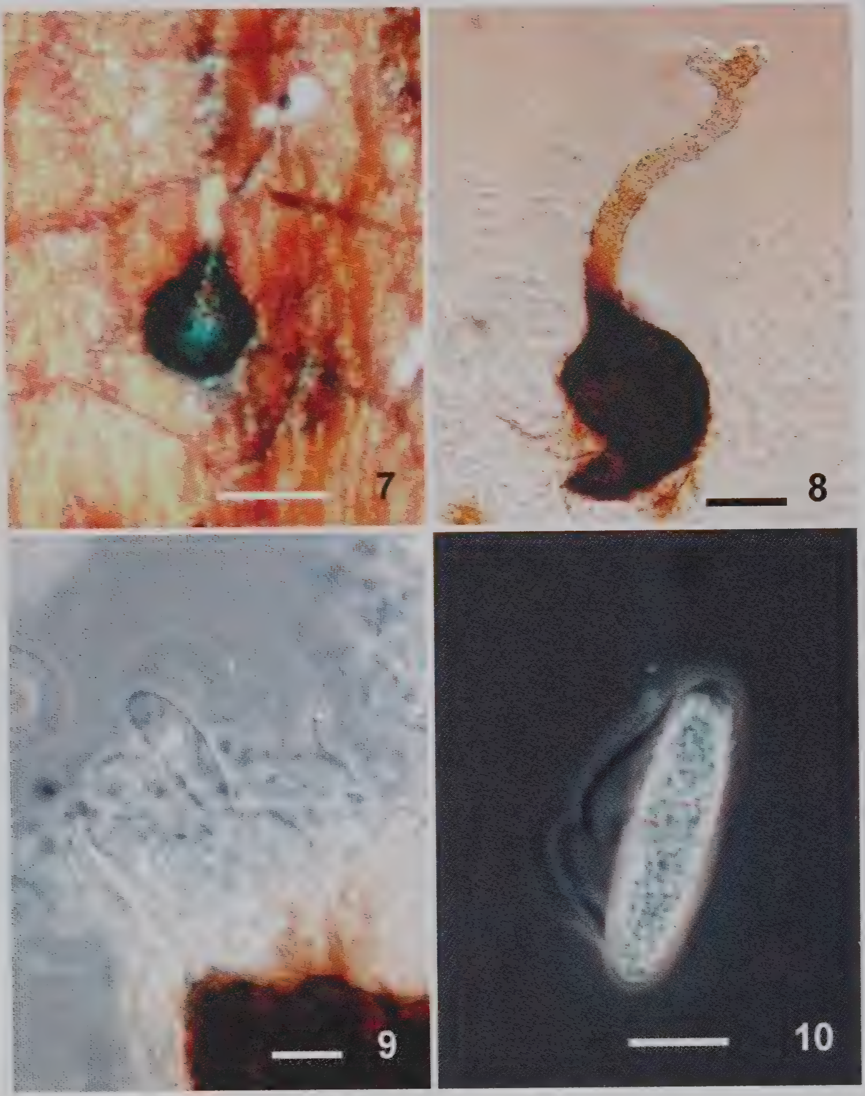
Material Examined — **MEXICO. Tabasco: Centro Municipality,** Las Ilusiones Lagoon (92°55'75" W 18°00'57"N) 24 Apr 2006, *E Rosique-Gil, MC González, J Cifuentes MGFW5* and slide 5 (MEXU 25351, *Pinus* sp. *wood test block submerged 3 mo and incubated 1 mo.*

Aniptodera inflatiascigera is very similar in ascospore form to other species, such as *A. fusiformis, A. limnetica* and *A. margarition,* in having hyaline, bi-celled thick-walled ascospores. However, *A. inflatiascigera* has larger ascospores (32–46 × 15–22 µm) compared to those of *A. fusiformis* (19–28 × 8–12 µm), *A. limnetica* (18–24 × 8–11 µm), and *A. margarition* (15–22 × 9–13 µm) (Shearer 1989, Tsui et al. 1997, Hyde et al. 1999). Also, *A. inflatiascigera* resembles *A. chesapeakensis* and *A. lignatilis* in the conspicuous retraction of cytoplasm in the ascus apices (Shearer & Miller 1977, Hyde 1992). The large asci that swell on release from the ascomata is an exclusive characteristic of *A. inflatiascigera*. The features of the Mexican specimen, however, agree with those of *A. inflatiascigera,* particularly the thick-walled ascospores (29–30 × 10–15 µm), the swollen asci, the thickened ascus apex and the subapical retraction of cytoplasm in the ascus.



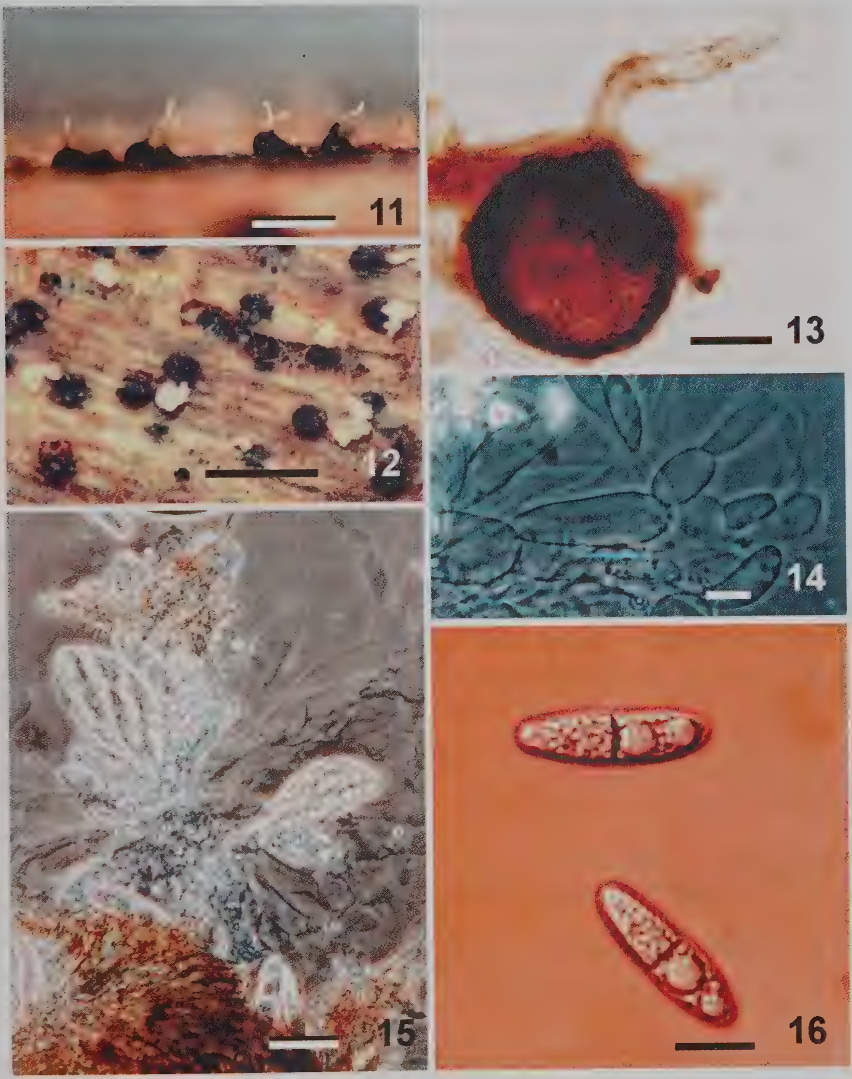
Figs. 1-6. *Aniptodera inflatiascigera*. 1. Ascoma on wood. 2. Conical, periphysate, hyaline neck with ascospores in canal. 3. Swollen asci. 4. Immature ascus and catenophyses. 5. Asci in various stages of development showing the apical thickening and cytoplasm retraction below the apex. 6. Thick-walled ascospores.

Bars 1 = 100 µm, 2 = 20 µm, 3, 4, 5 = 50 µm, 6 = 20 µm. Photomicrographs 1 taken with light microscopy, 2, 3, 6 with interference contrast microscopy and 4, 5 with phase contrast microscopy.



Figs. 7-10. *Ascosacculus aquaticus*. 7. Subglobose ascoma on wood. 8. Dark brown ascoma with hyaline neck with released ascospores. 9. Catenophyses. 10. Multiguttulate and unfurling appended ascospore.

Bars 7 = 200 µm, 8 = 100 µm, 9 = 10 µm, 10 = 10 µm. Photomicrographs 7 taken with light microscopy, 8 with interference contrast microscopy and 9, 10 with phase contrast microscopy.



Figs. 11-16. *Ascosacculus heteroguttulatus*. 11. Ascomata on wood. 12. Accumulation of ascospores at apex of ascomata. 13. Subglobose pigmented ascoma with hyaline neck. 14. Catenophyses. 15. Asci in various stages of development. 16. Ascospores with distinctive two guttules in one cell and numerous small guttules in the second cell.

Bars 11 = 500 µm, 12 = 100 µm, 13 = 500 µm, 14 = 10 µm, 15 = 20 µm, 16 = 10 µm . Photomicrographs 11, 12, 13 taken with light microscopy, 14, 15 with phase contrast microscopy and 16 with interference contrast microscopy.

In this study, this species occurred rarely on the submerged panel wood at lentic and heavily organic polluted urban environment. *Aniptodera inflatiascigera* is an uncommon and new ascomycete for Mexico. Known distribution from Brunei, Hong Kong and Philippines in lotic ecosistems (Tsui et al. 1997, Ho et al. 2001).

Ascosacculus aquaticus (K.D. Hyde) J. Campb., J.L. Anderson & Shearer, Mycologia 95: 545 (2003). **Figs. 7-10**

Material Examined — **MEXICO. Tabasco: Centro Municipality,** Las Ilusiones Lagoon (92°55'51" W 18°00'39"N) 24 Apr 2006, *E Rosique-Gil, MC González, J Cifuentes MGFW6* and slide 6 (MEXU 25352, *Tabubeia* sp. *wood test block submerged 3 mo and incubated 1 mo.*

Ascosacculus aquaticus has subglobose or pyriform 180–205 × 140–164 μm ascomata, immersed or semi-immersed, light brown or brown, membranaceous, ostiolate, with a neck, solitary or gregarious; long or short neck, up to 320 μm long, 30–42 μm diam, hyaline and periphysate; catenophyses present; saccate, 56 × 30 μm, 8-spored, thin-walled, with no apical thickening or pore, deliquescing early asci; fusiform or cylindrical ascospores, 33.5–64 × 7–10 μm, hyaline, bi-celled, sub-medial septa, thin-walled, highly guttulate, with hamate appendages at each end (Hyde 1992). The Mexican material has fusiform or cylindrical hyaline, bi-celled, sub-medial septa, thin-walled, highly guttulate, with hamate appendages at each end, but smaller ascospores (22–32 × 7–8 μm). However, the Mexican specimen is considered to be conspecific with *A. aquaticus*. This is the first record of *A. aquaticus* from lentic and heavy organic polluted freshwater environment from Mexico. Known distribution only of lotic ecosystems from Australia (Hyde 1992) and Costa Rica (Campbell et al. 2003).

Ascosacculus heteroguttulatus (S.W. Wong, K.D. Hyde & E.B.G. Jones) J. Campb., J.L. Anderson & Shearer, Mycologia 95: 545 (2003). **Figs. 11-16**

Material Examined — **MEXICO. Tabasco: Centro Municipality,** Las Ilusiones Lagoon (92°56'28" W 18°00'85"N) 4 Dec 2006, *E Rosique-Gil, MC González, J Cifuentes MGFW7* and slide 7 (MEXU 25353, *Pinus* sp. *wood test block submerged 3 mo and incubated 1 mo.*

Ascosacculus heteroguttulatus has black, globose to subglobose, 112-168 μm diam ascomata, immersed or superficial, with long neck; catenophyses present; early deliquescent 8-spored asci; ellipsoid 27–37 × 9–17.5 μm ascospores, 2-celled, hyaline, apical cell with one or two large lipid guttules, basal cell with numerous small guttules (Wong et al. 1998, Hyde et al. 1999, Anderson & Shearer 2002). The characteristics of the Mexican material agree with those of the protologue, particularly, the guttulate pattern of the ascospores and their size (20–27 × 7–9 μm). This species is new for Mexico and the only known distribution in Americas is from Florida, USA (Anderson & Shearer 2002) and Costa Rica (Campbell et al. 2003). Although this species was originally reported from Australia, Brunei, Hong Kong, Mauritius, Philippines and South Africa, the subsequent Americas records suggest a possible worldwide tropical and subtropical distribution of this fungus. Interestingly, the Mexican record of *A. heteroguttulatus* is the first from a heavily organic polluted urban body of water.

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New records and distribution of rust fungi from Pakistan

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Abstract — A contribution is made to the rust fungus flora of Pakistan with *Uromyces dactylidis*, *U. graminicola* and *U. peglerae* var. *peglerae* reported as new records for the country. New observations on previously known species are also noted. The spermogonia (0) of *Aecidium clematidis* and *A. montanum*, spermogonia (0) and aecia (I) of *Puccinia prenanthis* var. *himalensis* are described for the first time. *Phragmidium rosae-moschatae* on *Rosa webbiana* var. *microphylla*, *Puccinia levis* var. *panici-sanguinalis* on *Digitaria radicosa*, *P. conclusa* on *Cyperus iria*, and *Uromyces setariae-italicae* on *Setaria viridis* are new hosts for rust fungi in Pakistan.

Key words — biodiversity, *Melampsora epitea*, *Uredinales*, vegetation

Introduction

This paper is a continuation of the enumeration of the rust fungi from Pakistan (Afshan et al. 2007, Afshan et al. 2008a, Afshan et al. 2008b, Afshan et al. 2008c). Until now, only 21 genera and approximately 400 species of rust fungi are known from Pakistan (Ahmad et al. 1997, Afshan et al. 2007, Afshan et al. 2008). These figures indicate that the number of rust species collected from this area is far less than expected in relation to the vegetation. Comprehensive surveys of unexplored areas are needed to understand the biodiversity of *Uredinales* of Pakistan.

In the present investigation, *Uromyces dactylidis*, *U. graminicola* and *U. peglerae* var. *peglerae* are re-described and illustrated. These rust fungi are new to our rust flora. The spermogonia (0) of *Aecidium clematidis* and *A. montanum*, spermogonia (0) and aecia (I) of *Puccinia prenanthis* var. *himalensis* are reported for the first time from Pakistan. New hosts for Pakistan include *Clematis montana* for *Aecidium clematidis*, *Cyperus iria* for *P. conclusa*, *Digitaria radicosa* for *P. levis* var. *panici-sanguinalis*, *Panicum antidotale* for *Uromyces graminicola*, *Rosa webbiana* var. *microphylla* for *Phragmidium rosae-moschatae* and *Setaria viridis* for *Uromyces setariae-italicae*. New observations on previously known species were made. *Melampsora epitea*, *Phragmidium shogranense*, *Puccinia apludae*, *P. cirsii*, *P. helianthi*, *P. sorghi*, *Uromyces clignyi*, *U. ignobilis* and *U. orientalis*, already known from Pakistan, are reported from new localities.

Materials and methods

Free hand sections of infected portions of material and spores were mounted in lactophenol and gently heated to boiling. The preparations were observed under a NIKON YS 100 microscope. Drawings of spores and paraphyses were made using a camera lucida (Ernst Leitz, Wetzlar, Germany). Spore dimensions were measured using an ocular micrometer. At least 25 spores were measured for each spore stage.

Enumeration of taxa

1. ***Uromyces dactylidis*** G. H. Otth, Mitt. naturf. Ges. Bern: 85 (1861). **(Fig. 1)**

Spermogonia and aecia not seen. Uredinia on abaxial leaf surface brown, minute. Urediniospores globose to ovoid or broadly ellipsoid, 20–23 × 20–24 µm; wall 1.5–2 µm thick, hyaline to pale brown, echinulate; germ pores 5–7(–9), scattered, obscure; pedicel short, hyaline. Telia abaxial, mostly amphigenous, dark brown to blackish brown, subepidermal, loculate with brownish paraphyses. Teliospores ellipsoid to broadly ellipsoid or obovoid, (14–)16–23 × 20–26(–32) µm; wall 1.5–2 µm thick at side, 3–5 µm thick apically, brown to chestnut brown, smooth; apex mostly rounded, sometimes truncate; pedicel hyaline to yellowish, collapsing, 5–8 × 40 µm.

Material examined: On *Agrostis gigantea* Roth, Pakistan, North Western Frontier Province (NWFP), Khanspur, II + III, 24th May, 2006. # NSA 1706 (LAH).

Uromyces dactylidis is newly reported from Pakistan.

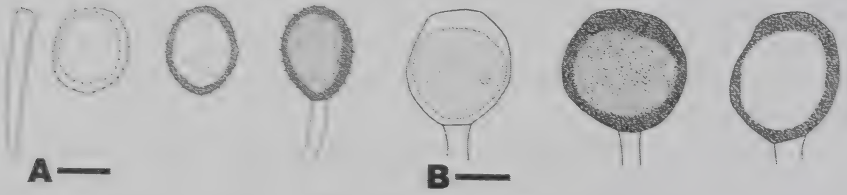

Fig. 1. *Uromyces dactylidis*
(A). Urediniospores showing germ pores and echinulate wall ornamentation (B). Teliospores.
Scale bar: 10 µm.

2. ***Uromyces graminicola*** Burrill, Bot. Gaz. 9: 188 (1884). **(Fig. 2)**

Spermogonia and aecia not seen. Uredinia amphigenous or mostly on adaxial surface, golden brown, minute. Urediniospores ellipsoid or obovoid but mostly broadly ellipsoid, (19–)20–24 × (20–)24(–28) µm; wall 1.5–2.5 µm

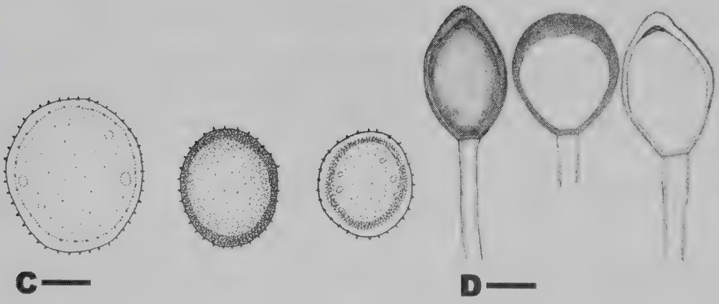

Fig. 2. *Uromyces graminicola* (C). Urediniospores (D). Teliospores. Scale bar: 10 µm.

thick, pale brown to golden brown, echinulate; germ pores 3–4, equatorial. Telia amphigenous, dark brown to blackish brown, early exposed. Teliospores ellipsoid to broadly ellipsoid or ovoid to obovoid, sometimes angular, 13–21 × (20–)22–30 µm; wall 1.5–2 µm thick at sides, 5–10 µm thick at apex, golden brown to chestnut brown, smooth; apex mostly rounded, sometimes conical, chestnut brown; pedicel hyaline to golden, persistent, 5–8 × 70–95 µm.

Material examined: On *Panicum antidotale* Retz., Pakistan, North Western Frontier Province (NWFP), Khanspur, II + III, 20th August, 2006. # NSA 2008 (LAH).

Uromyces graminicola is newly reported from Pakistan.

3. *Uromyces peglerae* Pole-Evans ex Syd. & P. Syd. var. *peglerae*, Ann. Mycol. 12: 263 (1914). (Fig. 3)

Spermogonia, aecia and telia absent. Uredinia abaxial, mostly on adaxial leaf surface, brown, 0.4–0.6 × 0.3–0.5 mm. Urediniospores globose to broadly ellipsoid or ovoid, 18–22 × 21–27 µm; wall thickness 1.5–2.0 µm, yellowish brown to dark brown, echinulate; germ pores 6–8, scattered or tending to be bizonate; pedicel hyaline, 6–8 × 45–50 µm.

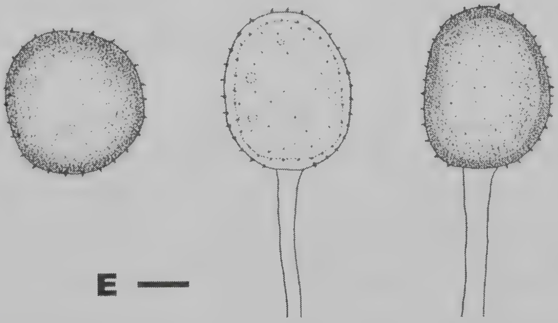

Fig. 3 (E). Urediniospores of *Uromyces peglerae* var. *peglerae*. Scale bar: 10 µm.

Material examined: On *Digitaria adscendens* (Kunth) Henrard (= *D. ciliaris* (Retz.) Koeler), Pakistan, Punjab, Lahore, II, 28th February, 2006. # NSA 2802 (LAH).

Puccinia digitariae-velutinae Vienn.-Bourg. has been reported on *Digitaria ciliaris* from Karachi (Ahmad et al. 1997). Cummins (1971) reported *Uromyces peglerae* var. *peglerae* on *Digitaria* spp. This rust is a new record for Pakistan.

4. *Aecidium clematidis* DC., in Lamarck & de Candolle, Fl. franç., Edn 3 (Paris) 2: 243 (1805). (Fig. 4)

Spermogonia adaxial, close to aecia, brown, in small groups, subepidermal, sunken in tissues of leaf, brown, 0.2–0.3 × 0.3–0.5 mm, with projecting ostiolar paraphyses, minute. Aecia abaxial, orange, in groups, cup-shaped, 0.1–0.2 × 0.2–0.3 mm. Aeciospores hyaline, ellipsoid to globose, 17–22(–24) × 17–26 μm, verrucose. Peridial cells hyaline, rhomboidal, 13–17(–24) × 16–24(–31) μm, verrucose.

Material examined: On *Clematis montana* Buch.-Ham., Pakistan, North Western Frontier Province (NWFP), Ayubia, 0 + I, 24th May, 2006. # NSA 2406 (LAH).

Ahmad (1956a, b) reported *A. clematidis* on *Clematis* spp. from Gilgit. The spermogonial stage of *A. clematidis* is herein described for the first time from Pakistan.

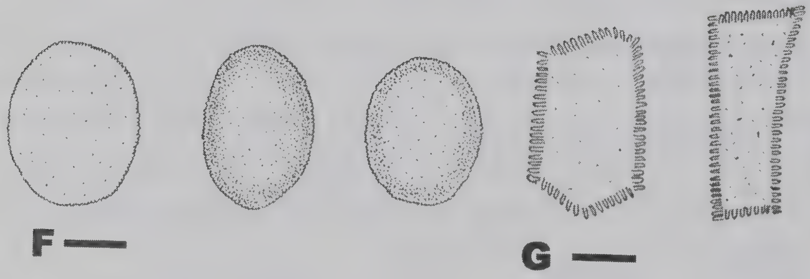

Fig. 4. *Aecidium clematidis* (**F**). Aeciospores (**G**). Peridial cells. Scale bar: 10 μm.

5. *Aecidium montanum* E. J. Butler, Indian Forester: 30 (1905). (Fig. 5)

Spermogonia adaxial, close to aecia, in small groups, subepidermal, sunken in leaf tissues, brown, 0.2–0.5 × 0.3–0.5 mm. Aecia abaxial, on yellowish orange spots with brown margins, in groups or scattered, localized, 0.1–0.4 × 0.2–0.41 mm, cylindrical or cupulate. Aeciospores hyaline to yellow, 15–21 × 24–28 μm, verrucose. Peridial cells hyaline, rhomboidal, 15–23 × 23–27 μm, verrucose.

Material examined: On *Berberis lycium* Royle, Pakistan, North Western Frontier Province (NWFP), Mukshupuri track, 0 & I, 23rd May, 2006. # NSA 2306 (LAH).

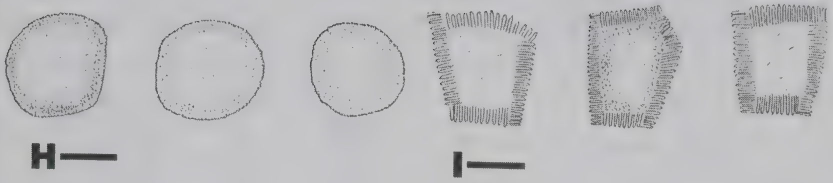

Fig. 5. *Aecidium montanum* (H). Aeciospores (I). Peridial cell. Scale bar: 10 μm.

Aecidium montanum has been reported on *Berberis pachyacantha* Koehne, *B. zabeliana* C. K. Schneid. and *B. lycium* from Chitral, Nathia galli, Changla galli, Kaghan valley, Quetta and Danyor (Ahmad 1956a). The spermogonial stage of this anamorphic rust is newly recorded for Pakistan.

6. ***Puccinia prenanthis*** var. ***himalensis*** Barclay,
Sci. Mem. Med. Off. Army India 6: 65 (1891). **(Fig. 6)**

Uredinia and telia absent. Spermogonia adaxial, scattered among aecia, white. Aecia abaxial, orange, in groups, cupulate. Aeciospores hyaline, obovoid to ellipsoid, 19–23(–25) × 21–25 μm; wall 2.5–3.5 μm thick, verrucose. Peridial cells hyaline, irregular in shape, (10–) 12–18(–24) × 15–18(–23) μm, verrucose.

Material examined: On *Lactuca brunoniana* (Wall. ex DC.) C. B. Clarke, Pakistan, North Western Frontier Province (NWFP), Ayubia, Mukshupuri track, 0 + I, 24th May, 2006. # NSA 24061 (LAH).

The aecidial and spermogonial stages of *P. prenanthis* var. *himalensis* on *L. brunoniana* are herein reported for the first time from Pakistan. Ahmad (1956a, b) reported the uredinial and telial stages of *P. prenanthis* var. *himalensis* on the same host from Kaghan valley, Shogran, Poonch and Changla galli.

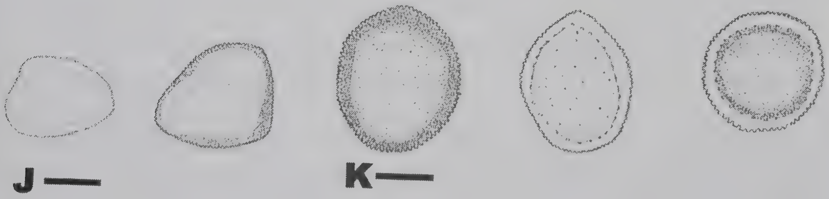

Fig. 6. *Puccinia prenanthis* var. *himalensis* (J). Peridial cells (K). Aeciospores. Scale bar: 10 μm.

7. ***Phragmidium rosae-moschatae*** Dietel, Hedwigia 44: 132 (1905). **(Fig. 7)**

Spermogonia, aecia and uredinia absent. Telia abaxial, black, 0.3–0.4 × 0.2–0.4 mm. Teliospores dark brown, mostly 6–7 celled, but 8-celled is also present; 29–34 × 55–106 µm, papilla 12–20 µm high, wall thickness 3–4 µm; pedicel up to 125 µm long.

Material examined: On *Rosa webbiana* var. *microphylla* Crép., Pakistan, North Western Frontier Province (NWFP), Khanspur, III, 05th August, 2006, NSA # 50806 (LAH).

Rosa webbiana var. *microphylla* is a new host for *Phragmidium rosae-moschatae* from Pakistan. Earlier, *Ph. rosae-moschatae* was reported on *Rosa brunonii* Lindl., (= *R. moschata* Herrm.), *R. lacerans* Boiss. & Buhse, *R. webbiana* Wall. ex Royle and *R. centifolia* L. from Quetta, Murree, Changla Gali, Peshawar, Tarnab (NWFP), Matiltan (Swat) and Battakundi (Kaghan Valley) (Ahmad et al. 1997).

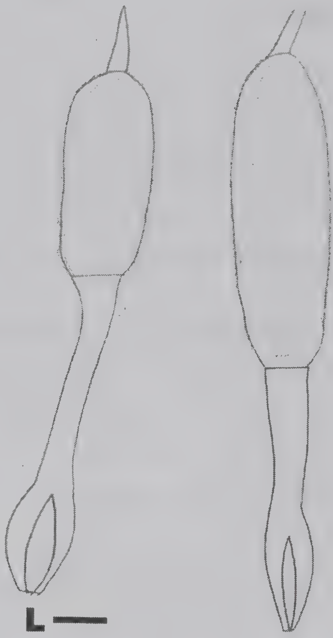

Fig. 7. (L). Teliospores of *Phragmidium rosae-moschatae*. Scale bar: 10 µm.

8. ***Puccinia levis*** var. ***panici-sanguinalis*** (Rangel) Ramachar & Cummins, Mycopath. Mycol. appl. 25(1-2): 44 (1965). **(Fig. 8)**

Spermogonia and aecia unknown. Uredinia hypophyllous, scattered, on leaf sheaths, in long linear rows, dark brown, 0.09–0.1 × 0.08–0.1 mm. Urediniospores globoid , obovoid or broadly ellipsoid, 20–25 × 21–29 µm, echinulate, pale brown to cinnamon brown, wall 1.5–2 µm thick at sides , 2–3 µm at the apex; germ pores 3–4, equatorial; pedicel hyaline and minute. Telia amphigenous, blackish brown, 0.09–0.2 × 0.1–0.3 mm. Teliospores ellipsoid to broadly ellipsoid, usually tending to be diorchidioid and often strongly so, 21–30 × 20–31 µm, wall 2–3 µm at sides while 4–7 µm thick over the pores, reddish brown to dark chestnut brown; germ pores obscure, scattered; pedicel colorless, persistent, 4–7 µm wide and up to 170 µm long

Material examined: On *Digitaria radicosa* (C. Presl) Miq., Pakistan, Punjab, Lahore, SHI Mycological Herbarium # NSA 16. 23rd October, 2006 (LAH).

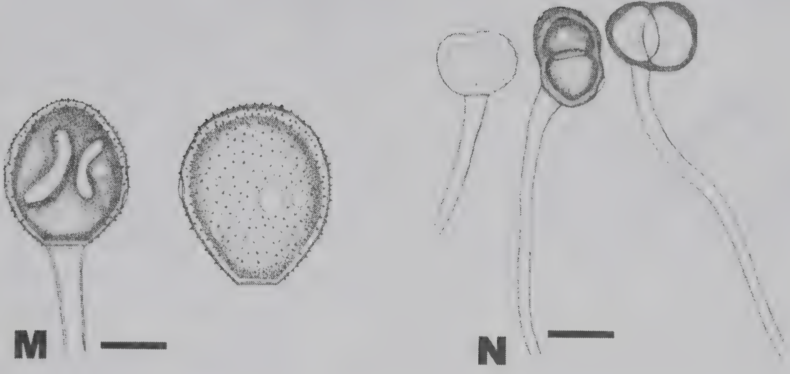

Fig. 8. *Puccinia levis* var. *panici-sanguinalis* (M). Urediniospores (N). Ellipsoid to diorchidioid type of teliospores. Scale bar: 10 µm.

Ahmad (1956a, b) reported *Puccinia levis* var. *panici-sanguinalis* as *Diorchidium digitariae* S. Ahmad on *Digitaria bicornis* (Lam.) Roem. & Schult. from Lahore. No rust fungus had previously been reported on *D. radicosa* from Pakistan. So *D. radicosa* is a new host for this rust species in Pakistan.

9. *Puccinia conclusa* Thüm.,
Journal Sci. math. phys. nat. Lisboa, 1 Ser. 6(no. 24): 237 (1878). **(Fig. 9)**
=*Puccinia romagnoliana* Maire & Sacc., Ann. Mycol. 1: 220 (1903).

Spermogonia and aecia unknown. Uredinia hypophyllous, brown, 0.2–0.3 × 0.09–0.1 mm. Urediniospores globose to subglobose or obovoid, brown, 18–21 × 21–28 µm, echinulate, wall 1.5–3 µm thick; germ pores 2, equatorial; pedicel hyaline, short. Telia hypophyllous, covered by epidermis, black, 0.2 × 0.1 mm, with brown paraphyses. Teliospores ellipsoid to clavate or oblong, pale brown, slightly constricted at septa, base attenuated, 13–21 × 44–60 µm; apex rounded or conical, 4–8 µm thick; wall 1–2 µm thick, smooth; pedicel pale brown, short, up to 40 µm long.

Material examined: On *Cyperus iria* L., Pakistan, Punjab, Lahore. SHI Mycological Herbarium, # NSA 17. 25th October, 2006 (LAH).

Puccinia conclusa has been reported under the name *P. romagnoliana* on *Cyperus difformis* L. and *C. rotundus* L. from Chuharkana (Sheikhupura) and Karachi by Ahmad (1956a, b), Ghaffar & Kafi (1968) and Hasnain et al. (1959) as listed in Ahmad et al. (1997). Ahmad (1956a, b) reported *P. philippinensis* Syd. & P. Syd. and *P. cypericola* S. Ahmad on *Cyperus rotundus*. No rust species has previously been reported on *Cyperus iria* from Pakistan. So *C. iria* is also a new host for *P. conclusa* in Pakistan.

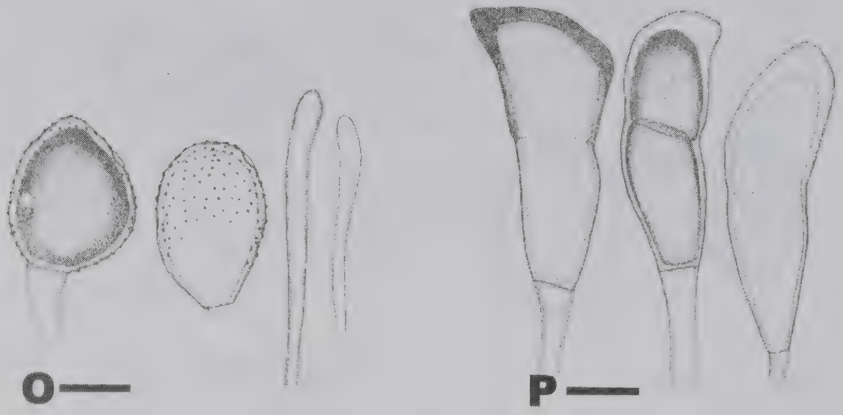

Fig. 9. *Puccinia conclusa*
(O). Urediniospores and paraphyses (P). Ellipsoid to clavate teliospores. Scale bar: 10 μm.

10. ***Uromyces setariae-italicae*** Yoshina, Bot. Mag. Tokyo. 20: 247 (1906). **(Fig. 10)**

Spermogonia and aecia not seen. Uredinia amphigenous, scattered or in rows, pulverulent, brown, 0.09–0.1 × 0.1–0.3 mm. Urediniospores subglobose to ovoid or ellipsoid, brown to yellowish brown, echinulate, 23–27.5 × 23–29 μm; wall 1.5–2.5 μm thick; germ pores up to 4, equatorial; pedicels hyaline, up to 40 μm long. Telia amphigenous, covered by the epidermis, blackish, small and inconspicuous, striated, 0.05–0.2 × 0.09–0.2 mm. Teliospores one celled, variable, mostly angularly globoid or obovoid, 16–24 × 19–28 μm, wall uniformly 1–2 μm thick, smooth, yellowish brown to chestnut brown; apex not thickened, rounded or truncate. Pedicel hyaline, collapsing, 4 × 15 μm.

Material examined: On *Setaria viridis* (L.) P. Beauv., Pakistan, North Western Frontier Province (NWFP), Khanspur, II + III, 15th September, 2006. # NSA 1509 (LAH).

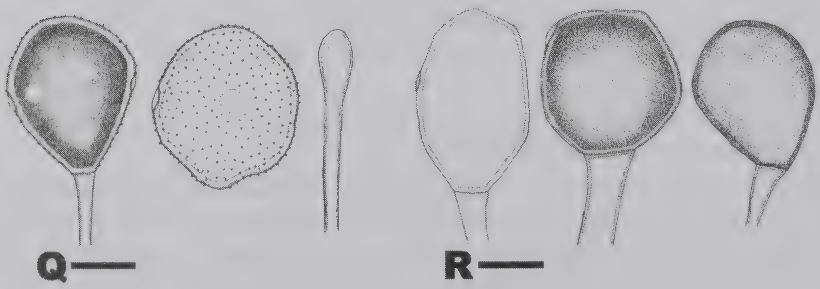

Fig. 10. *Uromyces setariae-italicae*
(Q) Urediniospores with a paraphysis. (R) Teliospores. Scale bar: 10 μm.

Ahmad (1956a, b) reported *Uromyces setariae-italicae* on *Urochloa reptans* (L.) Stapf as *Brachiaria reptans* (L.) C.A. Gardner & C.E. Hubb. and *S. glauca* from Lahore, Sheikhupura and Tandojam. *Setaria viridis* is a new host for *Uromyces setariae-italicae* in Pakistan.

11. ***Melampsora epitea*** Thüm., Mitth. forst. Versuchs. Öster. 2: 38 (1879).

Melampsora epitea is reported for the first time from Dunga galli. It is already reported on leaves of *Salix* spp., and *S. tetrasperma* from Kaghan valley, Batal, Swat and Hasanabad by Ahmad (1956a, b), Malik & Virk (1968) and Ahmad & Arshad (1972); from Choa Saiden Shah by Khalid et al. (1993a); on *S. flabellaris* Andersson, from Kaghan valley by Ono (1992).

Material examined: On *Salix tetrasperma* Roxb., Pakistan, North West Frontier Province (NWFP), Bhoorban, Dunga Galli, II. Aug. 10, 2006. NSA # 1008 (LAH).

12. ***Phragmidium shogranense*** Petr., Sydowia, 8: 162 (1954).

This rust has been previously reported on *Rubus* sp. from Kaghan valley and Swat by Ahmad (1956a, b), additional hosts include *R. pedunculosus* D. Don and *R. pungens* Cambess. (Khalid et al. 1993b) and *R.* aff. *biflorus* Buch.-Ham. ex Sm. from Kaghan valley (Ono 1992).

Material examined: On *Rubus* sp., Pakistan, North West Frontier Province (NWFP), Khanspur, II + III, 10th Sep., 2006. NSA # 1009 (LAH).

13. ***Puccinia apludae*** Syd. & P. Syd. Annls mycol. 4: 436 (1906).

Puccinia apludae was previously reported on leaves of *Apluda mutica* L. from Charsadda by Ahmad & Arshad (1972) but is herein reported for first time from Khanspur (NWFP).

Material examined: On *Apluda aristata* L., Pakistan, North West Frontier Province (NWFP), Khanspur, II+III, June 23, 2006. NSA # 2305 (LAH).

14. ***Puccinia cirsii*** Lasch, in Rabenhorst, Fungi europ. exsicc.: no. 89 (1859).

Ahmad (1956a, b) reported *P. cirsii* on *Cnicus argyracanthus* from Swat state and Madian, on *C. wallichii* Hook. f. from Swat state, Kalam and Changla galli, and on *Cnicus* sp. from Kaghan Valley and Shogran. It is an addition to the rust fungi of Khanspur (NWFP).

Material examined: On *Cnicus argyracanthus* C. B. Clarke, Pakistan, North West Frontier Province (NWFP), Khanspur, II, Aug. 10, 2006, NSA # 100806 (LAH).

15. ***Puccinia helianthi*** Schwein., Schr. naturf. Ges. Leipzig 1: 73 (1822).

Puccinia helianthi is reported for the first time from Lahore. It has been previously reported on *Helianthus annuus* from Karachi, Peshawar, Rawalpindi, Quetta and Tandojam (Ahmad et al. 1997).

Material examined: On *Helianthus annuus* L., Pakistan, Punjab, Lahore, II, Aug. 9, 2006, NSA # 90806 (LAH).

16. ***Puccinia sorghi*** Schwein., Trans. Am. phil. Soc., n.s. 4(2): 295 (1832).
=*Puccinia maydis* Berenger, Atti Riunione Sci. Ital. 6 (Milano 1844): 475 (1845).

Puccinia sorghi has been previously reported on leaves of *Zea mays* from Quetta, Kaghan, Kulali, Swat, Lahore, Karachi, Tandojam, Balakot, Naran, Sharan and Shogran (Ahmad et al. 1997), but this is a new record for Khanspur, NWFP.

Material examined: On *Zea mays* L., Pakistan, North West Frontier Province (NWFP), Khanspur, III, Aug. 23, 2006. NSA # 2307. (LAH).

17. ***Uromyces clignyi*** Pat. & Har., J. Bot. Morot 14: 237 (1900).
=*Uromyces andropogonis-annulati* Syd., P. Syd. & E.J. Butler, Annls mycol. 5(6): 492 (1907).

Ahmad (1956a) reported *Uromyces clignyi* from Gillanwali, Sangla Hill, Rawalpindi, Kulali, Swat, Kalam, Karachi, and Gujranwala, but it is a new record for Lahore.

Material examined: On *Dichanthium annulatum* (Forssk.) Stapf, Pakistan, Punjab, Lahore, II, Sep. 20, 2006, NSA # 2009 (LAH).

18. ***Uromyces ignobilis*** (Syd. & P. Syd.) Arthur, Mycologia 7(4): 181 (1915).

This species has been previously reported on leaves of *Sporobolus arabicus* from Lahore by Ahmad (1956a, b) and Masood et al. (1995), but this is the first report on *S. arabicus* from Khanspur (NWFP).

Material examined: On *Sporobolus arabicus* Boiss., Pakistan, North West Frontier Province (NWFP), Khanspur, II, May 23, 2006, NSA # 2305 (LAH).

19. ***Uromyces orientalis*** Syd. & P. Syd., Annls mycol. 5(6): 490 (1907).

Uromyces orientalis is reported for the first time from Lahore. It has been previously reported on *Indigofera linifolia* from Sheikhupura, Zafarwal and Gujrat by Ahmad (1956a, b, 1964a).

Material examined: On *Indigofera linifolia* (L. f.) Retz., Pakistan, Punjab, Lahore, II+III, Sep. 20, 2006. NSA # 20091 (LAH).

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Additions to the corticioids of the Caucasus from NW Iran

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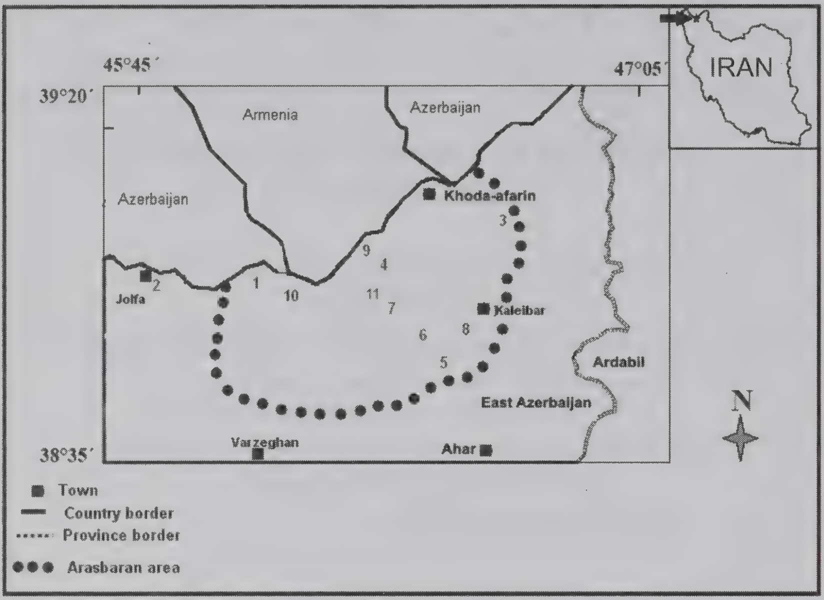
Abstract — A recent survey of wood-inhabiting *Basidiomycota* in NW Iran added 11 corticioids new to Iran, 6 of which are reported for the first time from the Caucasus area. Additional finds of 10 rarely collected species in Iran are presented and data on their occurrence in the Caucasus is also summarised. Most of the species are illustrated and ecological and distribution notes are provided. Some rare or otherwise noteworthy records are *Hyphodontia erastii, Melzericium bourdotii, Peniophora laeta,* and *Tubulicrinis incrassatus.*

Key words — Arasbaran, *Corticiaceae* s.l.

Introduction

The Caucasus region, covering an area of some 532,700 km^2 between Black Sea and Caspian Sea, comprises the countries Georgia, Armenia, Azerbaijan, parts of European Russia, NE Turkey, and NW-N Iran. The montane forests of the Arasbaran area and Talish forests in NW Iran, as well as the Hyrcanian forests constitute the southern stretches of the Caucasus.

Intensive survey on wood-inhabiting *Basidiomycota* (polypores and corticioids) in N Iran was carried out by Hallenberg during 1978–81 (Hallenberg 1978, 1979, 1980, 1981). Recent collections were made by Ghobad-Nejhad during 2005–06 in NW Iran, mainly in Arasbaran area. Situated in the northern part of East Azerbaijan province, Arasbaran (Qara daq) covers an area of 900,000 hectares and belongs to the sub-humid zone in the northwest of Iran. The vegetation is dominated by *Quercus* spp. and *Carpinus betulus,* accompanied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■ Town
— Country border
······ Province border
●●● Arasbaran area

Fig. 1. Localities visited in Arasbaran area, NW Iran. For description of numbers see Table1.

with *Juniperus* spp., *Taxus baccata, Fraxinus rotundifolia, Lonicera* spp., *Acer campestre* etc. A large part of the Arasbaran area is covered by high peaks and steep slopes. The area is affected from the west by mediterranean climate and coincides in the south with Irano-Turanian steppes. Talish mountains in the east connect the area to Hyrcanian forests, which have a markedly different vegetation composition due mainly to their different amount of annual rainfall. Arasbaran lacks some relict Hyrcanian elements such as *Parrotia persica, Quercus castaneifolia,* etc. The area is threatened by over-grazing and logging (e.g. Jalili et al. 2003).

Mycological inventories in the Arasbaran area are scanty, and none (if any) is focused on wood-inhabiting *Basidiomycota*. These fungi, traditionally referred to as corticioids and polypores, are distributed mainly in the orders *Corticiales, Gloeophyllales, Hymenochaetales, Russulales, Thelephorales,* and *Trechisporales,* all belonging to *Agaricomycetes* Doweld (sensu Hibbett et al. 2007).

This paper concentrates on new or some less collected corticioids from NW Iran. Corticioids have for a long time been treated under the collective family name *Corticiaceae* s.l. Larsson's (2007) proposed set of fifty families to accommodate the corticioid species is still regarded as provisional and awaits further modification.

Table 1. Localities visited in NW Iran, E Azerbaijan province, and some of their attributes. Numbers in the parentheses are shown in Fig. 1.

Locality	Important vegetations	Alt. (m)	Coordinates
Jolfa, Missan (1)	*Acer monspessulanum, Paliurus spina-christi, Carpinus betulus, Quercus* sp., *Juniperus excelsa*	820-1372	N38°51’: E46°26’
Jolfa, Daran (2)	*Juglans regia, Prunus armeniaca*	1300	N38°39’: E46°21’
Shah-heidar (3)	*Juniperus* sp., *Paliurus spina-christi*	700	N39°01’: E46°50’
Vaighan (4)	*Quercus* sp., *Carpinus betulus, Taxus baccata, Juniperus communis*	1350	N38°52’: E46°49’
Makidi valley (5)	*Quercus macranthera, Carpinus betulus, Acer campestre, Fraxinus exelsior, Fraxinus rotundifolia*	1400	N38°50’: E46°55’
Kolashloo (6)	*Quercus* sp., *Carpinus betulus*	1820-1850	N 38°51’: E46°52’
Balan (7)	*Quercus* sp., *Acer* sp., *Lonicera* spp., *Viburnum lantana*	2100	N 38°59’: E 47°29’
Qale-darasi (8)	*Quercus* sp., *Carpinus betulus*	1800	N 38°50’: E47°00’
Kalale (9)	*Cornus mas, Carpinus betulus, Taxus baccata, Acer* sp., *Quercus* sp.	1200	N 38°56’: E 46°45’
Oshtobin (10)	*Paliurus spina-christi, Amygdalus* sp., *Quercus* sp., *Lonicera* spp., *Cornus mas, Cotinus coggygria*	1150	N38°50’: E46°29’
Aynaloo (11)	*Quercus* sp., *Carpinus betulus, Acer campestre, Lonicera caucasica*	1750	N38°50’: E46°47’

Materials and methods

Material for this study was collected during two visits to Arasbaran area, in October–November 2005 and 2006. Additional material collected from Russian Caucasus and NE Turkey during 1989–96 is also added to the examined specimens in the text. Species are treated alphabetically in two sections: first comes a list of new records, followed by the list of some little collected corticioids. An asterisk (*) symbolises the new records to the Caucasus, and a filled circle (•) marks records new to Iran. Old and recent accounts of all species in the Caucasus, if applicable, are outlined and brief notes on substrates and distribution are given. Specimens were examined in 5% potassium hydroxide (KOH), Melzer´s reagent (IKI) and Cotton Blue (CB). Measurements and drawings were mainly made in CB. A drawing tube was used when making line drawings. Iranian specimens are maintained in Ghobad-Nejhad ref. herb. and some of dublicates are deposited in H. Material from the Russian Caucasus and NE Turkey are kept in GB. The collecting localities in NW Iran are mapped in Fig. 1 and the assigned numbers are explained in Table 1. These numbers are used when examined specimens are listed, to avoid redundancy. The author names are abbreviated as MG, NH, and HK in the text and/or beside collection numbers. The nomenclature of species follows Cortbase version 2.02 (accessed 2007).

New records

*• 1. ***Acanthophysellum minor*** (Pilát) Sheng H. Wu, Boidin & C.Y. Chien FIG. 2

≡*Aleurodiscus cerussatus* var. *minor* Pilát
≡*Acanthophysium minor* (Pilát) Tellería

Aleurodiscus cerussatus var. *minor* (Pilát 1926) was raised to species rank in *Acanthophysium* by Tellería (1991), and subsequently transferred to *Acanthophysellum* by Wu et al. (2000). Tellería & Melo (1995) stated that *Acanthophysium cerrusatum* differs from *A. minor* by spore size: 10–14 × 7–9 µm in the former and 7–10 × 5–7 µm in the latter. Spores in the Iranian specimens measure 6.5–9.5 × 3.5–6 µm.

On dead wood of both angio- and gymnosperms. Most of the known distribution for the species is given under *Acanthophysellum cerussatum* (Bres.) Parmasto in a wide sense (=*Aleurodiscus cerussatus* (Bres.) Höhn. & Litsch.) which is also known in Southern Hemisphere (see Hjortstam & Ryvarden 2007a, b). According to Tellería & Melo (1995), *A. minor* is common on branches of different hardwoods in dry and sunny places in Iberian Peninsula.

SPECIMENS EXAMINED — **Iran.** Loc (3), on fallen twig under *Juniperus* sp. and *Paliurus spina-christi*, 01.X.2006 MG 363; on litter under *Juniperus* sp., MG 366. **Croatia.** Mt. Vipera, on *Pinus nigra*, IV.1940, K.H. Rechinger & Litschauer, no. 1538 (H).

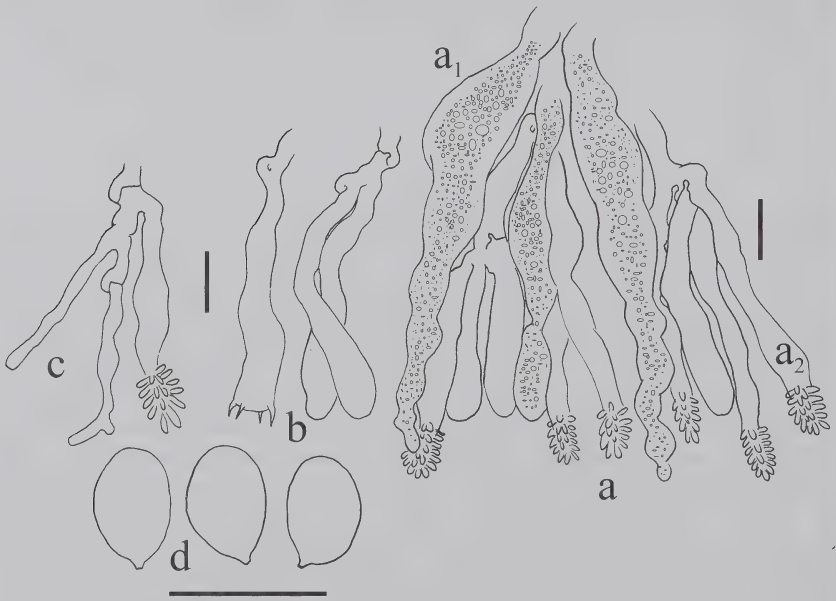


Fig. 2. *Acanthophysellum minor.* a) Section of hymenium with gloeocystidia (a_1) and acanthophyses (a_2), b) basidia, c) dendrohyphidia, d) basidiospores. MG 366. Scale bar=10 µm.

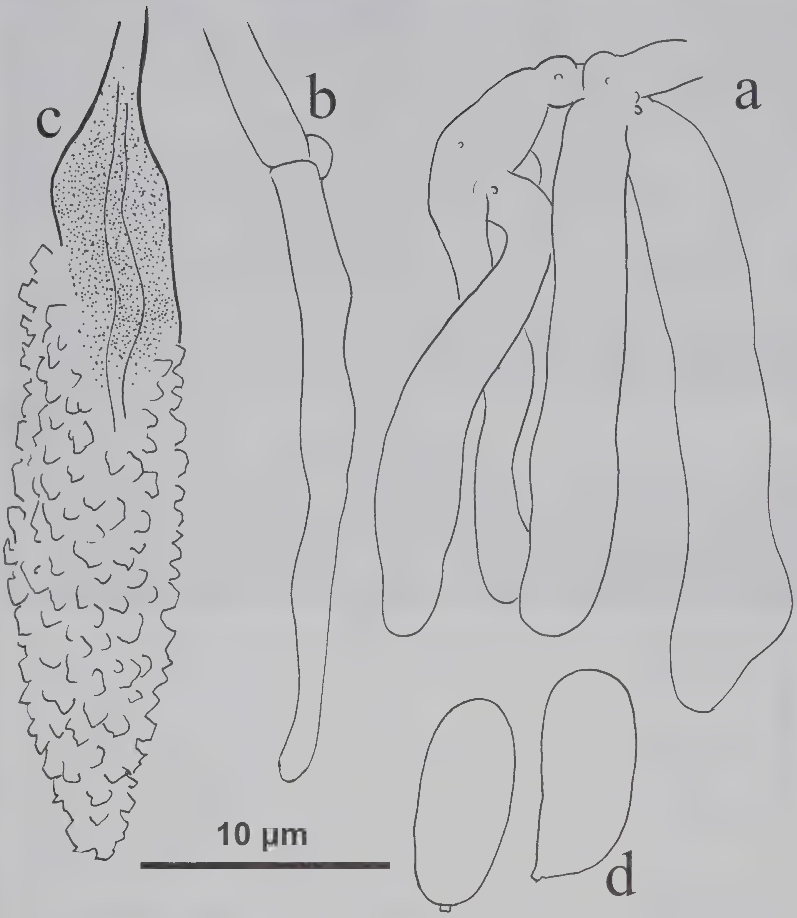


Fig. 3. *Amylostereum laevigatum.*
a) Basidia, b) young cystidium, c) mature cystidium, d) basidiospores. MG 383.

• 2. ***Amylostereum laevigatum*** (Fr.) Boidin FIG. 3

A. laevigatum is closely related to *A. ferreum* (Berk. & M.A. Curtis) Boidin & Lanq. (see e.g. Tabata et al. 2000, Slippers et al. 2002), which, however, is known only from S. America.

The species was earlier reported in the NW Caucasus by Mukhamedshin (1992) on *Taxus* in *Fagus-Abies* belt (1000–1350 m). In Iran it was collected on bark of a conifer, fallen in a mixed open forest, and in Russian Caucasus it was found on log of *Taxus* in mixed deciduous forest of colchic type with evergreen understory.

The species has been recorded from conifers in Northern Hemisphere. In Japan, it was reported as a symbiont occurring in mycangia of a female wasp and attacks *Abies firma*, *A. homolepis*, *Cryptomeria japonica*, and *Picea jezoensis*, leading to the discoloration of the wood (Tabata & Abe 1999). In Switzerland it is associated with stem canker of *Taxus baccata* (Hassler et al. 2004).

SPECIMENS EXAMINED — **Iran.** Loc. (4), on conifer, 02.X.2006 MG 383. **Russia.** Krasnodar, 2 km NE Chosta, on *Taxus*, 09.VIII.1996 NH 12967.

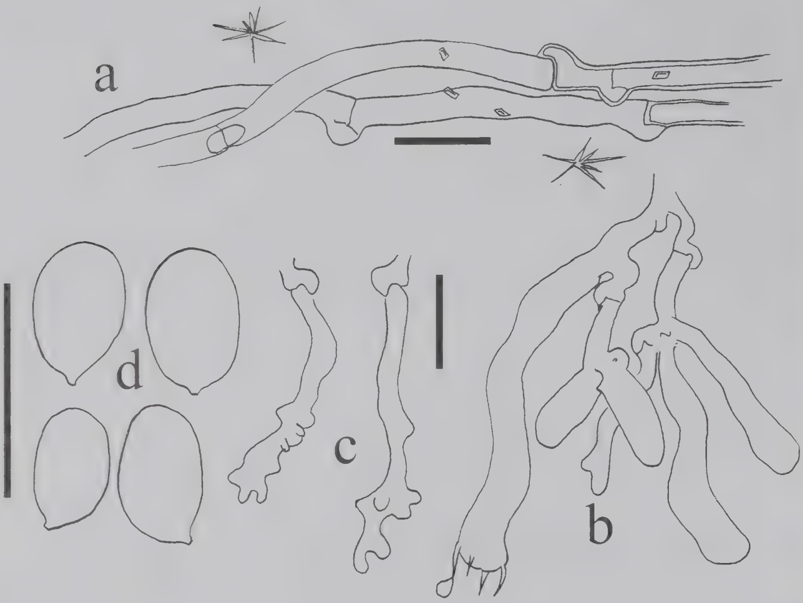


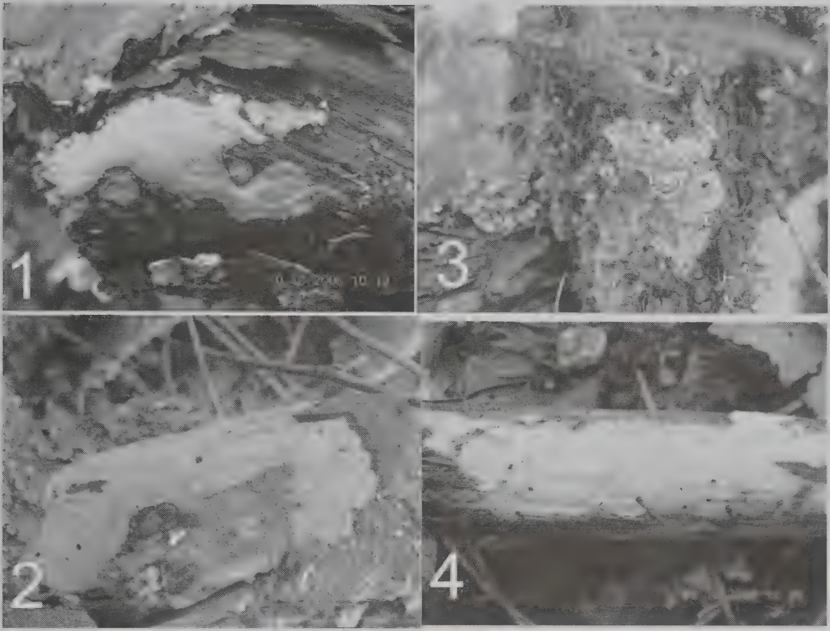
Fig. 4. *Dendrocorticium polygonioides*.
a) Subicular hyphae, b) basidia, c) dendrohyphidia, d) basidiospores. MG 504.
Scale bar=10 µm.

*• 3. ***Dendrocorticium polygonioides*** (P. Karst.) M.J. Larsen & Gilb.

≡*Corticium polygonioides* P. Karst FIG. 4, PHOTO. 1

In the specimen from Iran, dendrohyphidia are less branched and spores are shorter (6.1 × 4.1 µm), compared to Larsen & Gilbertson (1977) and Maekawa (1994). This may refer to the young stage of the fruitbody.

On different hardwoods. Africa and Europe. Asia: Japan on decaying branch of *Fagus crenata* (Maekawa 1994), Russia, Nizhny Novogrod region, on *Quercus*



Photos. 1-5. Photographs of basidiocarps taken in the field. Photo. 1. *Dendrocorticium polygonioides,* MG 504. Photo. 2. *Megalocystidium luridum,* MG 455. Photo. 3. *Scytinostroma aluta,* MG 369. Photo. 4. *Hyphoderma nemorale,* MG 480.

(Spirin 2002, mentioned to be one of the characteristic species of virgin oak-forest in that region), Iran.

Specimen examined — **Iran.** Loc (10), on decorticated fallen branch of *Quercus* sp., decay class 3, 10.X.2006 MG 504.

•4. ***Hyphoderma litschaueri*** (Burt) J. Erikss. & Å. Strid Fig. 5

The earlier report of *H. litschaueri* from Iran by Hallenberg (1981) was later shown to be *Hyphoderma nemorale* (see below). Mukhamedshin (1992) reports *H. litschaueri* from NW Caucasus on *Betula* in subalpine belt (1650–2200 m). However, we could not confirm the identification.

In NW Iran it was collected on fallen log of *Carpinus betulus,* and in Russian Caucasus on branch of *Quercus* in *Quercus* forest with *Fagus sylvatica, Prunus* and *Rhododendron.*

On decayed wood of different angiosperms. North America, Spain (GBIF: www.gbif.org), Norway (Hansen & Knudsen 1997), Sweden (Toresson 1994), Carpathian Mountains (Eriksson & Ryvarden 1975), Italy (Mayrhofer et al. 2001), Russia, South America and Australia (Hjortstam & Ryvarden 2007a), Iran.

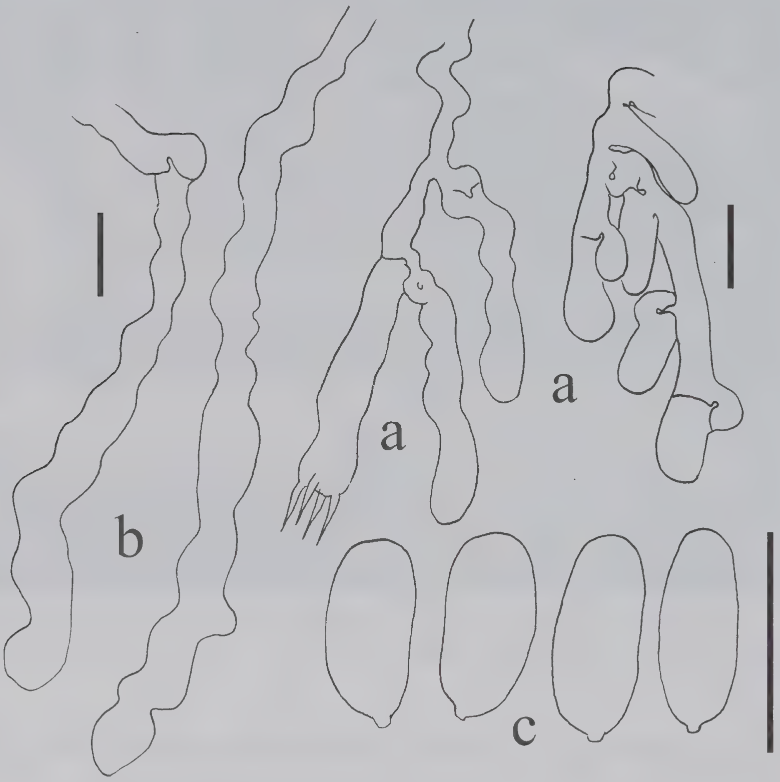


Fig. 5. *Hyphoderma litschaueri.*
a) Basidia, b) cystidia, c) basidiospores. MG 462. Scale bar=10 µm.

Specimens examined — **Iran.** Loc. (8), on *Carpinus betulus,* 05.X.2006 MG 462. **Russia.** Krasnodar, Lazarevskaja , alt. 410 m., N43°41′: E39°42′ on *Quercus,* 11.IX.1996 NH 12999 and NH 13006.

*•5. ***Hyphodontia erastii*** Saaren. & Kotir. Fig. 6

H. erastii belongs to *Hyphodontia sambuci* (Pers.) J. Erikss. group and is distinguished by having fewer subulate cystidia, smaller capitate cystidia and narrower, subcylindrical spores (Kotiranta & Saarenoksa 2000).

Four Iranian specimens were collected on fallen twigs of *Carpinus betulus* and on decayed twig of deciduous tree.

So far known on: *Angelica sylvestris, Arctium tomentosum, Caragana* sp., *Carpinus betulus, Filipendula ulmaria, Phragmites, Sambucus kamtschatica,* and *S. racemosa,* mostly in semi-natural forests. Finland, Russia (Kotiranta &

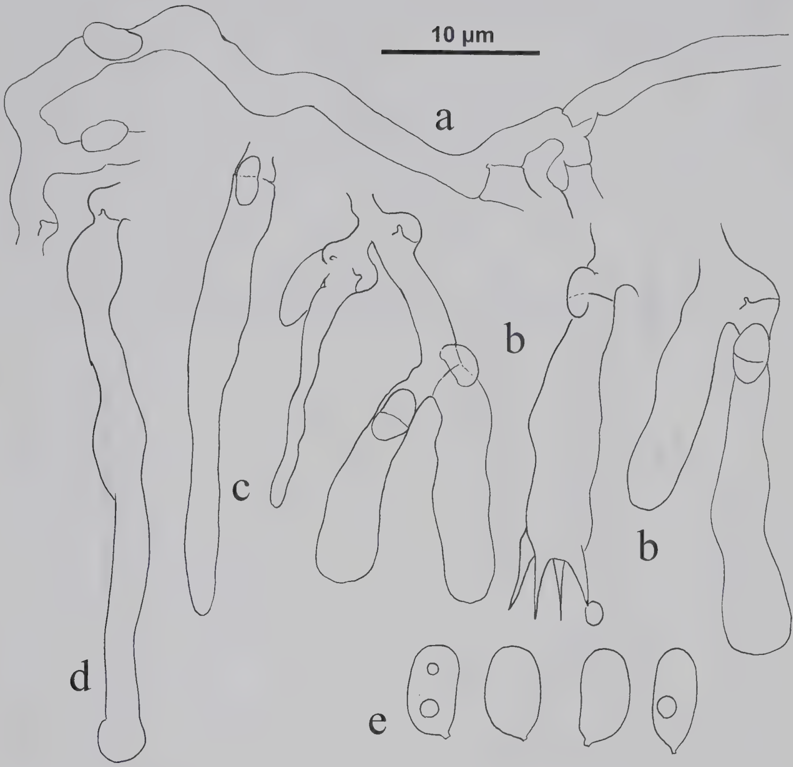


Fig. 6. *Hyphodontia erastii.*
a) Hyphae of subiculum, b) Basidia , c) subulate cystidium,
d) capitate cystidium, e) basidiospores. MG 430.

Saarenoksa 2000), the Netherlands (Heller & Keizer 2004), regarded as critically endangered in Czech Republic (Holec & Beran 2006), Iran.

Specimens examined — **Iran.** Loc. (1), on deciduous twig, 29.IX.2006 MG 328: Loc. (6), on *Carpinus betulus,* 04.X.2006 MG 430; Loc. (8), on *Carpinus betulus,* 05.X.2006 MG 445, 465.

•6. ***Megalocystidium luridum*** (Bres.) Jülich Fig. 7, Photo. 2
≡*Gloeocystidiellum luridum* (Bres.) Boidin

Known from Azerbaijan on branch of *Pterocarya pterocarpa* (Parmasto 1965, denoted: exemplar non typicum). The single specimen from Iran was found on moderately decayed, decorticated standing stump of *Carpinus betulus.*

Mostly on angiosperms. Europe, Morocco (Malençon 1982), China (Dai et al. 2004), Azerbaijan, Iran.

Specimens examined — **Iran.** Loc (8), on *Carpinus betulus*, 05.X.2006 MG 455.

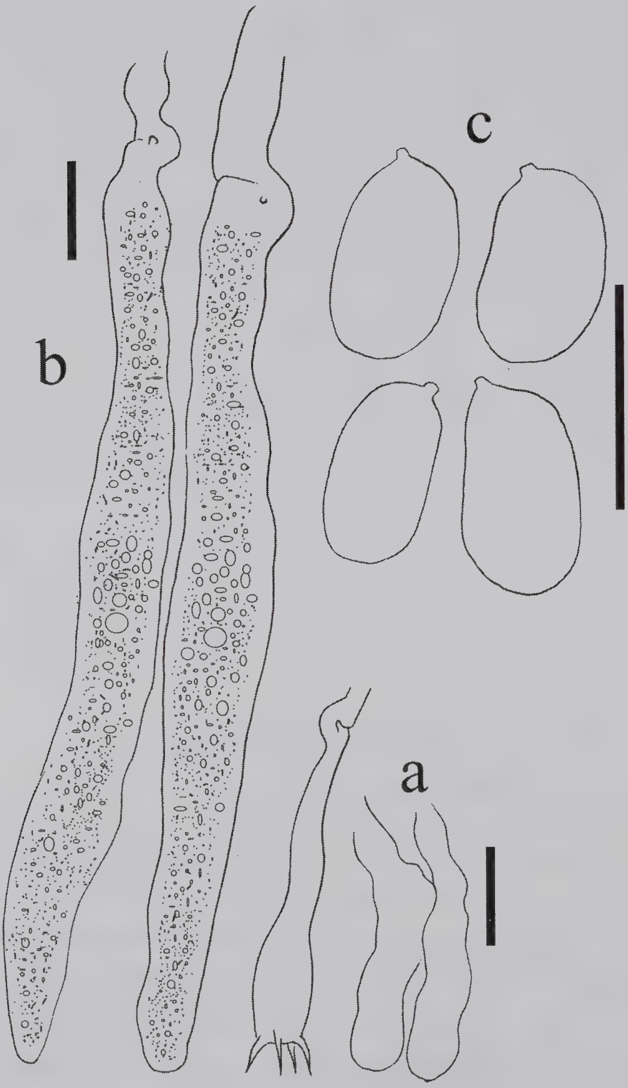


Fig. 7. *Megalocystidium luridum.*
a) Basidia, b) gloeocystidia, c) basidiospores. MG 455.
Scale bar=10 µm.

*•7. *Melzericium bourdotii* Jülich Fig. 8

Jülich (1976) distinguished *M. bourdotii* from *Melzericium udicola* (Bourdot) Hauerslev essentially based on spore shape, which is "distinctly constricted in the middle (like a dumb-bell)" in the former. Still, the taxon with bean- or kidney-shaped spores is called *M. udicola* in most literature. A re-examination of both types combined with DNA analysis is needed to solve if two taxa are involved in practice.

The specimen from Iran was collected on fallen twig of *Juniperus communis*.

Only sparse data is available for this species. Canada, Ontario, on *Populus*? (de Vries 2004), France on *Salix caprea* (type), Norway on hard moist fallen

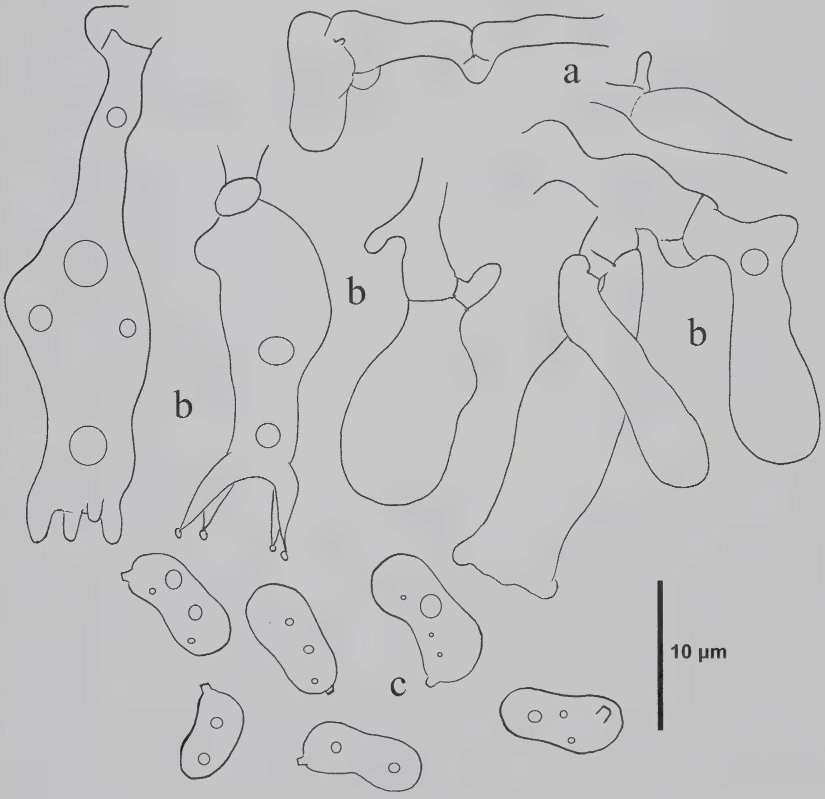


Fig. 8. *Melzericium bourdotii*.
a) Hyphae, b) basidia, c) basidiospores. MG 395A.

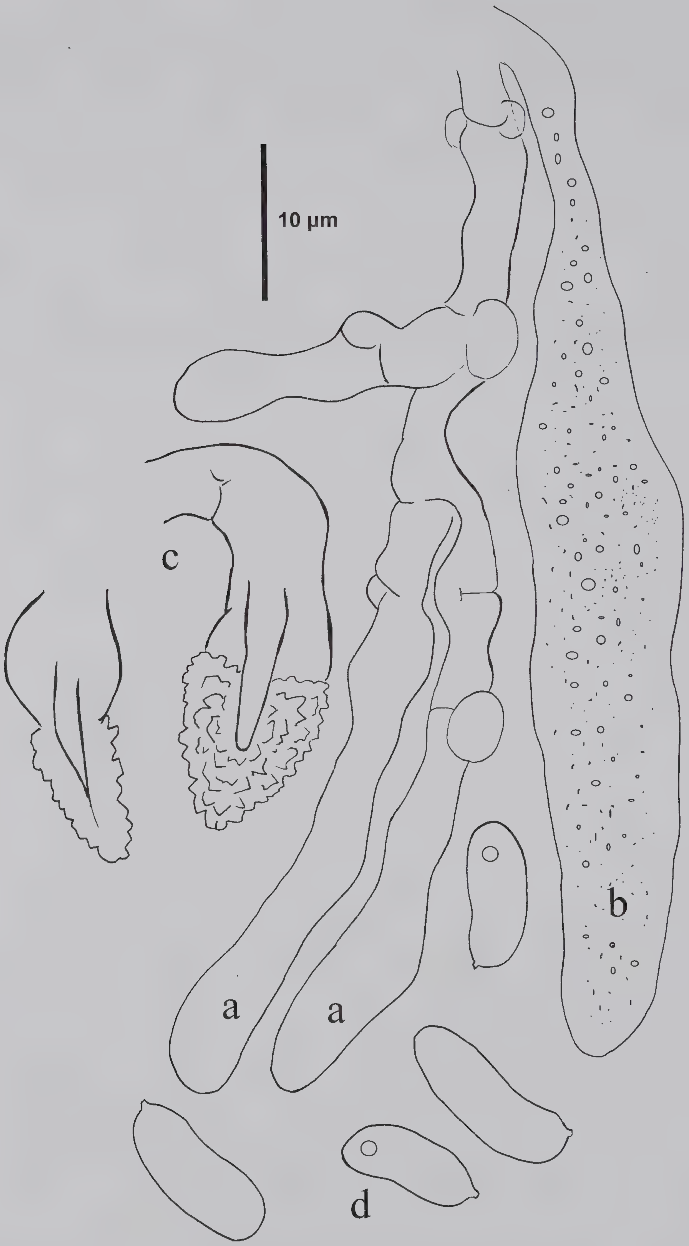


Fig. 9. *Peniophora laeta.*
a) Basidia, b) gloeocystidium, c) encrusted cystidia, d) basidiospores. MG 327.

trunk of *Alnus* (Strid 1975, Ryvarden et al. 2003), Sweden (Hauerslev 1974). The only known collection on conifer is from Iran, on *Juniperus communis.*

Specimens examined — **Iran.** Loc. (4), on *Juniperus communis,* 02.X.2006 MG 395A.

*•8. ***Peniophora laeta*** (Fr.) Donk Fig. 9

Reminiscent of *Peniophora incarnata* (Pers.) P. Karst. which is found on cut surfaces of wood. *P. incarnata* grows on different hosts, whereas *P. laeta* inhabits primarily corticated branches of *Carpinus betulus* where it grows on primary cortex and pushes away the secondary layers of bark with hyphal pegs (e.g. Eriksson et al. 1978).

Zugmaier et al. (1994) studied the mycoparastism of *Peniophora laeta* by *Tremella mesenterica* Retz., growing on *Carpinus betulus.* In Iranian material, at least in one occasion (no. 413A) the fruitbodies of *T. mesenterica* were close to *P. laeta.*

In NW Iran *P. laeta* commonly inhabits corticated fallen or live twigs and branches of *Carpinus betulus.* Found in Russian Caucasus on *Carpinus* in mixed riverside forest, and in NE Turkey in mixed forest on unidentified deciduous branch.

Mostly on corticated branches of *Carpinus betulus* in Europe. In N America on *Amelanchier pallida* and *A. utahensis* (Ginns & Lefebvre 1993). Unterseher & Tal (2006) recorded it on strongly decayed wood of *Tilia cordata* in Germany. Apparently its easternmost known locality is in Iran.

Specimens examined — **Iran.** Loc. (1), on hardwood twig, 29.IX.2006 MG 327 and on *Carpinus betulus,* MG 337; Loc. (5), on *Carpinus betulus,* 03.X.2006 MG 413A; Loc. (11), on *Carpinus betulus,* 29.IIX.2005 MG 119. **Russia.** Krasnodar, Lazarevskaja, on *Carpinus,* 19.IX.1996 NH 13150. **Turkey.** Trabzon, Sumela monastery, 1000–1100 m, on hardwood branch, 02-04.X.1989 NH 11381.

• 9. ***Scytinostroma aluta*** Lanq. Fig. 10, Photo 3

Hallenberg (1985) discussed similar species and their distinguishing features.

S. aluta was earlier recorded from Stavropol, Russian Caucasus by Bondartseva & Parmasto (1986). In NW Iran it was collected on dead but still attached, corticated branches of *Paliurus spina-christi,* and on fallen twig of *Lonicera* sp. In both cases the substrate was white-rotted. It has also been sampled in NE Turkey on *Sambucus nigra* branch in a mixed *Picea orientalis* forest with *Fraxinus* and *Alnus barbata.*

Submediterranean species (Hallenberg 1985) on different hardwoods. Bondartseva & Parmasto (1986) give more extended account of its hosts and distribution.

Specimens examined — **Iran.** Loc. (3), on *Paliurus spina-christi,* 01.X.2006 MG 369; Loc. (6), on *Lonicera* sp., 04.X.2006 MG 434. **Turkey.** Trabzon, Sumela monastery, 1000–1100 m., on *Sambucus,* 02—04.X.1989 NH 11368.

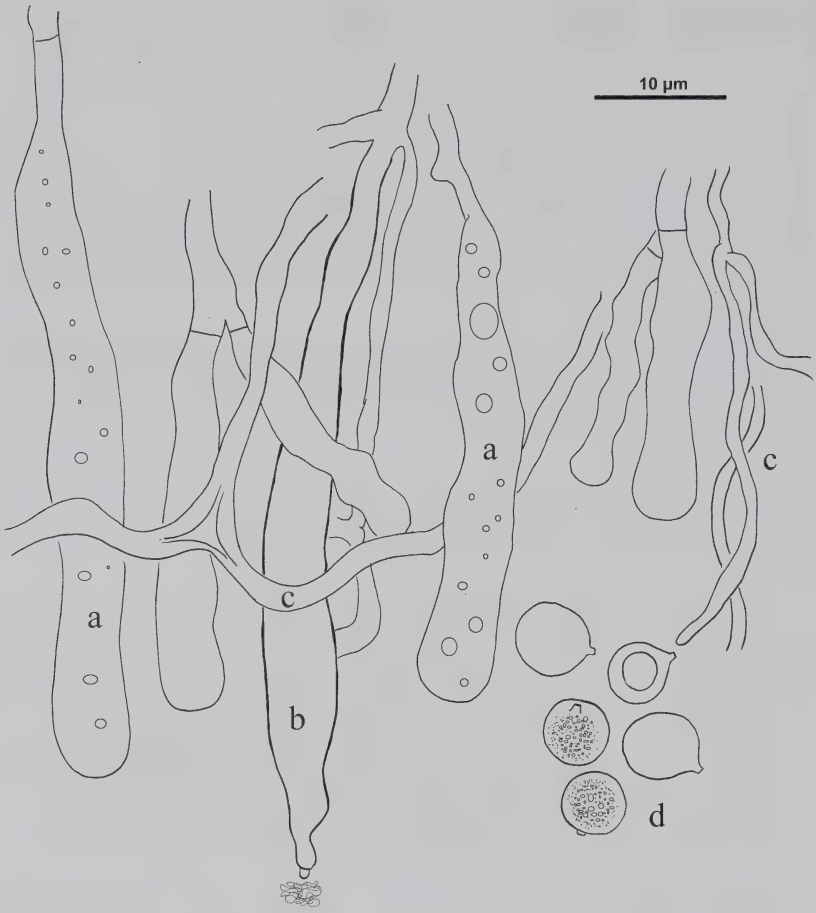


Fig. 10. *Scytinostroma aluta.*
a) Basidia, b) cystidium, c) dendrohyphidia, d) basidiospores. MG 434.

*• 10. ***Tubulicrinis cinctus*** G. Cunn. Fig. 11

=*Tubulicrinis cinctoides* Hjortstam

The cystidia in Iranian specimen are frequently coiled with the hyphae of another fungus (Fig. 12c). These may belong to *Colacogloea bispora* (Hauerslev) Oberw. & R. Bauer. However basidia with only one sterigma were visible (not shown in Fig. 11), and the other sterigma is apparently behind the cystidia. Moreover the shape of the spores does not fully agree with *C. bispora,* and only a few germinated spores were seen, but no really repetitive spores. Therefore we are not fully sure of its identity. Only few encrustations were seen around the neck of *T. cinctus* cystidia.

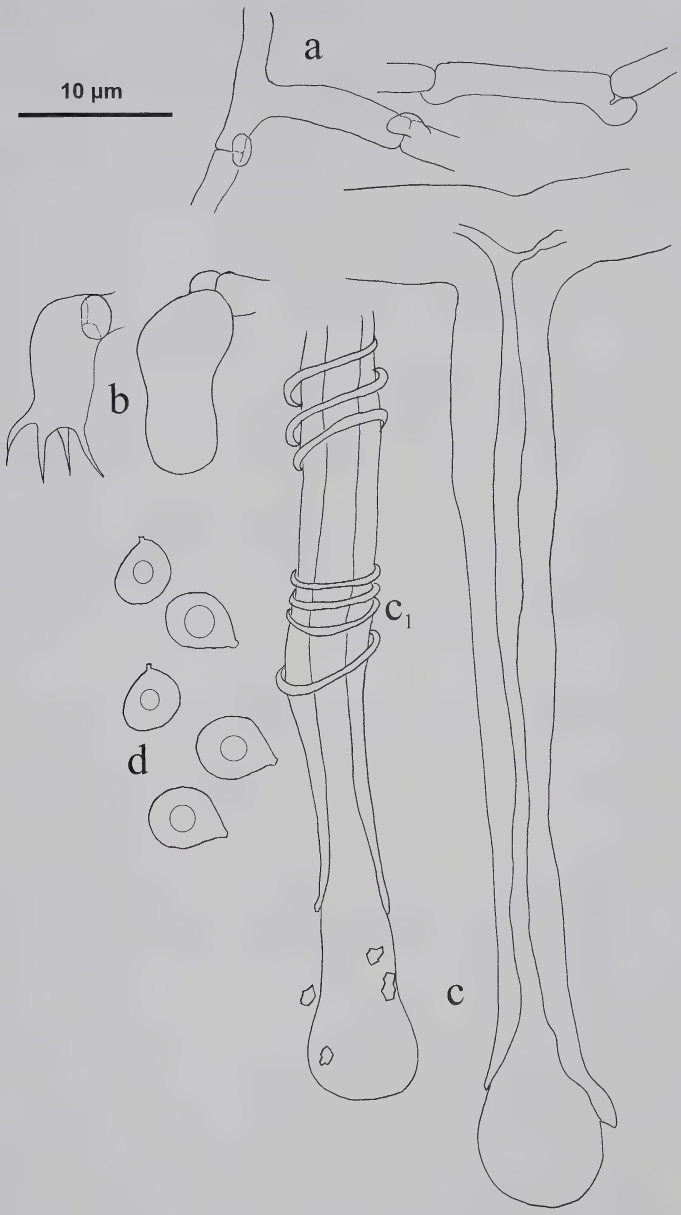


Fig. 11. *Tubulicrinis cinctus.*
a) Hyphae in subiculum, b) basidia,
c) cystidia frequently coiled with the hyphae of unknown fungus (c$_1$), d) basidiospores. MG 472A.

In Iran, on stump of *Taxus baccata,* accompanied with *Radulomyces rickii.* Russian Caucasus, on a fallen log of *Abies* on northern slope of an *Abies* forest.

On dead wood of conifers viz. *Abies, Dacrydium cupressinum, Picea,* and *Taxus baccata.* N Europe, Russia, Turkey, Iran, China (Maekawa et al. 2002), New Zealand.

Specimens examined — **Iran.** Loc. (9), on *Taxus baccata,* 06.X.2006 MG 472A. **Russia.** Krasnodar, Mostovskoj, 1700 m, on *Abies,* 11.IX.1991 NH 12182.

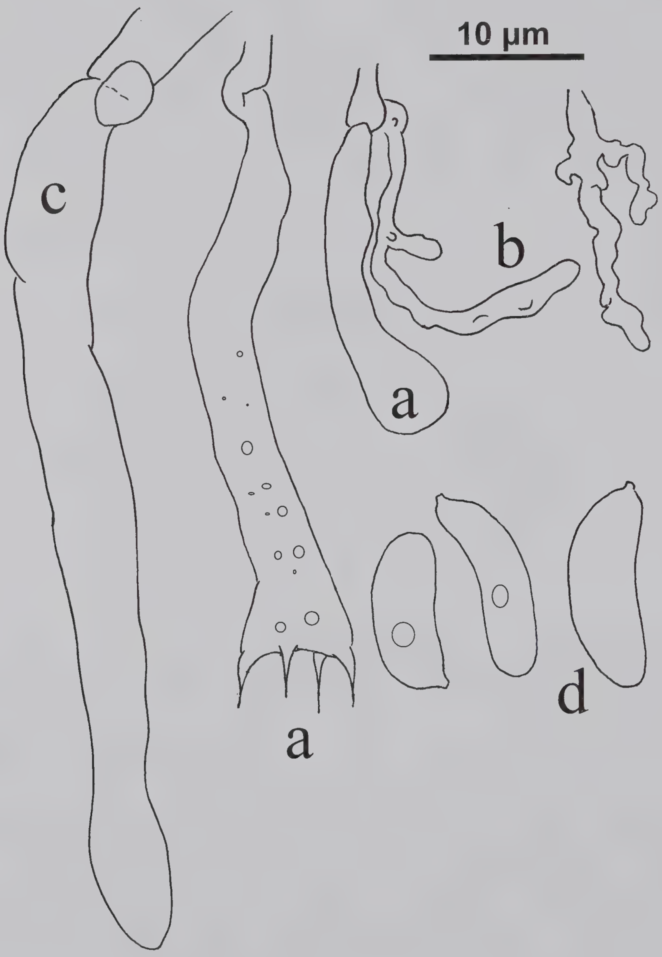


Fig. 12. *Vuilleminia coryli.*
a) Basidia, b) dendrohyphidia, c) cystidium, d) basidiospores. MG 319.

• 11. ***Vuilleminia coryli*** Boidin, Lanq. & Gilles FIG. 12

Vuilleminia coryli comes close to *V. cystidiata* Parmasto but the latter has subulate cystidia (obtuse in *V. coryli*) and smaller spores.

Reported from NW Caucasus by Mukhamedshin (1992) on *Corylus* in *Quercus* belt (650–750 m), *Fagus* belt (750–1000 m), and *Fagus-Abies* belt (1000–1350 m).

In Iran on decorticated snag of *Crataegus* sp. This substrate seems unusual for *V. coryli,* since the association with hosts from *Rosaceae,* and *Crataegus* in particular, has used to be a distinguishing feature for *V. cystidiata.* In Russian Caucasus, as well as NE Turkey, *V. coryli* was consistently collected on *Corylus* in a variety of luxuriant forests.

Usually on *Corylus.* England (Legon et al. 2005, also single collections on *Acer campestre, Salix caprea* and *Sambucus nigra*), France (Boidin et al. 1989, once on *Acer campestre*), Basque (Salcedo 1994), Luxemburg (Tholl et al. 2000), N Europe (Hansen & Knudsen 1997), Russia, Turkey, Iran.

SPECIMENS EXAMINED — **Iran.** Loc. (1), on *Crataegus* sp., 29.IX.2006 MG 319. **Russia.** Krasnodar, Mostovskoj 1700 m, 11.IX.1991 NH 12164; Lazarevskaja , Baranovka, alt. 60 m., N43°42′: E39°41′, 08.VIII.1996 NH 12911; Krasnodar, Lazarevskaja , 19.IX.1996 NH 13142; Adler, Estosadok. alt. 240 m, 15.IX.1996 NH 13091. **Turkey.** Trabzon, vicinity of Malavaci. alt. 1200 m, N40°52′: E39°37′, 26.IX.1996 Hallenberg 13262. (all on *Corylus*).

Additional finds of species rarely collected in Iran

Twelve species collected previously only once or twice in Iran are listed, and their occurrence in the Caucasus is summarized.

1. ***Athelia arachnoidea*** (Berk.) Jülich FIG. 13

Although *A. arachnoidea* is a quite common species, the only earlier report is the two collections made by Hallenberg (1981) on fallen branches in N Iran.

In NW Iran five samples (all fertile) were collected on fallen corticated branches and twigs or on fallen bark of *Quercus* and *Paliurus spina-christi.* Spore shape in one collection is unusual (Fig. 14) and their size is small, 6.5 x 5.5 µm. One fruitbody (no. MG 306) was accompanied with *Stereum hirsutum,* and one collection (no. MG 373) parasitized the lichen *Pleurosticta acetabulum.* No data on the occurrence of its anamorph *Fibulorhizoctonia carotae* (Rader) G.C. Adams & Kropp in Iran was found.

In NE Turkey collected on *Picea* log, in *Fagus, Abies, Picea* forest.

Mostly on angiosperms, rarely recorded on gymnosperms. Distributed in all continents, but reports from Asia are few, not yet known in China and Japan (cfr. Dai et al. 2004 and Maekawa 1993, respectively).

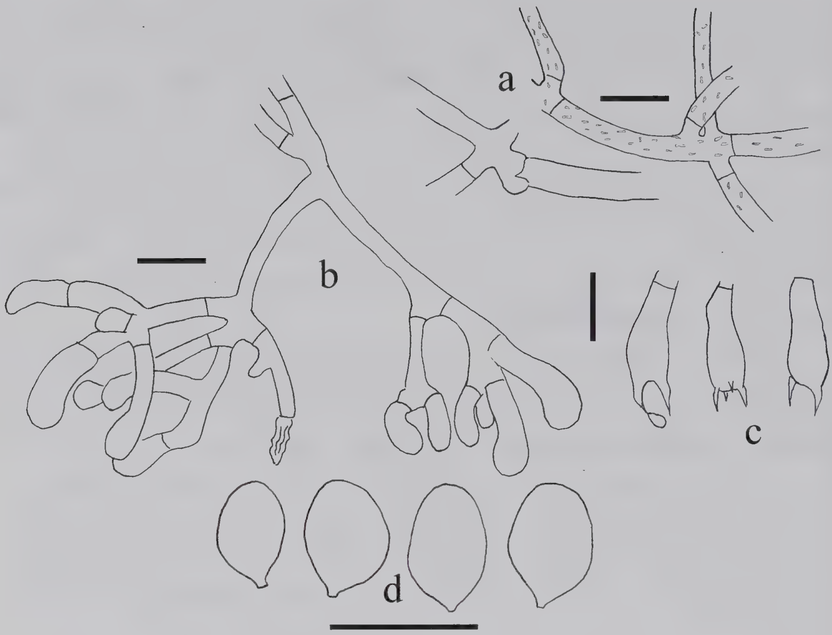


Fig. 13. *Athelia arachnoidea.*
a) Hyphae in subiculum, b) a section of hymenium, c) basidia, d) basidiospores. MG 306.
Scale bar=10 µm.

Specimens examined — **Iran.** Loc. (1), on *Quercus,* 29.IX.2006 MG 306; Loc. (3), on *Paliurus spina-christi,* MG 373, on felled bark, MG 375; Loc. (4), on *Quercus,* MG 376; Loc. (10), on *Quercus,* MG 491. **Turkey.** Cilekli Agacli, 1400 m, on *Picea,* 10.X.1989 NH 11518.

2. ***Ceraceomyces serpens*** (Tode) Ginns

≡*Ceraceomerulius serpens* (Tode) J. Erikss. & Ryvarden

Earlier records were made by Hallenberg (1981) on a fallen branch of *Fagus orientalis* in N Iran, by Mukhamedshin (1992) in *Quercus* belt (650–750 m) and *Fagus* belt (750–1000 m) on *Sambucus* and *Corylus* in NW Caucasus. Gvritishvili et al. (2007) mention it for Borjomi, Georgia. New collections were made on decorticated fallen branches of *Juniperus communis.*

Found in many parts of the world, on both angio- and gymnosperms.

Specimens examined — **Iran.** Loc. (4), on *Juniperus communis,* MG 383a, 395.

3. *Corticium roseum* Pers.

≡*Laeticorticium roseum* (Pers.) Donk

Earlier reports in N Iran: on fallen logs of *Fagus* and *Quercus* (Hallenberg 1981). In the Caucasus: Gardabani and Abkhasia, Georgia (Gvritishvili et al. 2007); NW Caucasus on *Salix, Populus,* and *Fagus* in all four vegetation belts (see Mukhamedshin 1992).

Collections in NW Iran were made on decorticated and corticated, dead, but still attached branches and twigs of *Carpinus betulus* and on cut surface of an unidentified dead angiosperm. In Russian Caucasus on a still attached branch of *Populus* and log of *Alnus* in mixed forests.

More often on hardwood. Found in all continents except in S America.

SPECIMENS EXAMINED — **Iran.** Loc. (8), on *Carpinus betulus,* MG 448; Loc. (9), on *Carpinus betulus,* MG 471; Loc (10), on angiosperm, MG 518. **Russia.** Krasnodar, Mostovskoj, alt. 1000 m, on *Populus,* 07.IX.1991 NH 12037; Adler, N43°39′: E40°27′ alt. 930 m, on *Alnus,* 21.IX.1996 NH 13238; Estosadok. alt. 240 m, on *Alnus,* 15.IX.1996 NH 13086.

4. *Hyphoderma nemorale* K.H. Larss.

FIG. 14, PHOTO. 4

Denoted for Iran by Larsson (1998) on *Fagus orientalis* (Hallenberg 1981: sub *Hyphoderma cremeoalbum* (Höhn. & Litsch.) Jülich and *H. litschaueri*). In the present study 10 collections in Arasbaran were made on *Carpinus betulus* and *Quercus* sp., mostly on dead, fallen, decorticated branches and twigs, which sometimes were considerably decayed. On some branches were also *Hyphoderma setigerum* s.l., *Irpex lacteus,* and *Skeletocutis nivea.*

Often found on small corticated branches and twigs of different hardwoods in boreal and nemoral zones (Larsson 1998). The occurrences here on mostly decorticated branches point towards *Hyphoderma incrustatum* K.H. Larss. (Larsson 1998), but microscopically they fit *H. nemorale.*

No data about the species in other parts of the Caucasus is available.

SPECIMENS EXAMINED — **Iran.** Loc (1), on *Carpinus betulus,* 29.IX.2006 MG 339; on angiosperm, MG 340a; Loc. (5), on *C. betulus,* 03.X.2006 MG 417; on *Quercus,* MG 421; Loc. (8), on fallen twig of *C. betulus,* 05.X.2006 MG 444; on *C. betulus,* MG 449, 456; on *C. betulus,* MG 454; Loc. (9), on angiosperm, 06.X.2006 MG 480 and on *Quercus,* MG 489.

5. *Hyphodontia subalutacea* (P. Karst.) J. Erikss.

Previously reported from N Iran by Hallenberg (1981) on fallen, white-rotted branches of *Fagus orientalis.* From NW Caucasus by Mukhamedshin (1992) on *Pinus* in *Abies* belt (1350–1650 m) and Subalpine belt (1650–2200 m).

The majority of the reported collections were made on conifer branches. In Iran on dead, decorticated hanging branch of *Juniperus communis* , dead, decayed but still attached burnt branch of *Cornus mas,* and on brown-rotten

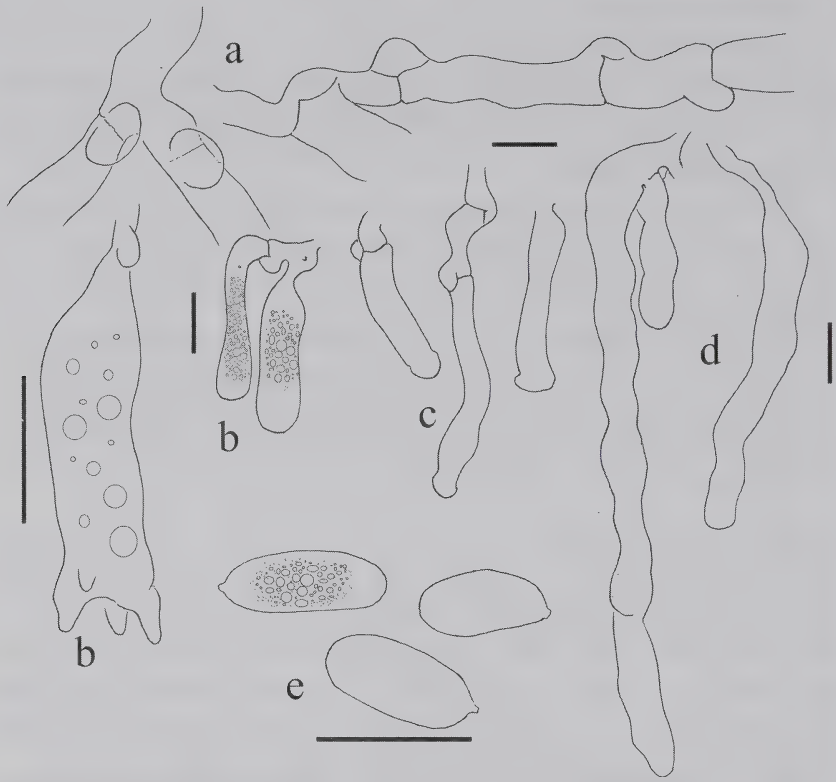


Fig. 14. *Hyphoderma nemorale.*
a) Hyphae in subiculum, b) basidia, c) hymenial cystidia, d) enclosed cystidia,
e) basidiospores. MG 417. Scale bar=10 µm.

fallen branch of *Quercus.* In Russia on *Abies* in *Abies* forest and on *Pinus* in *Pinus-Quercus* forest. In Turkey on *Picea* in a pure *Picea orientalis* stand.

On both angio- and gymnosperms with worldwide distribution.

Specimens examined — **Iran.** Loc. (1), on fallen decorticated branch of *Quercus*; Loc. (4), on *Juniperus communis,* 02.X.2006 MG 384; Loc. (9), on *Cornus mas,* 06.X.2006 MG 473. **Russia.** Krasnodar, Mostovskoj, 1700 m, on *Abies,* 11.IX.1991 NH 12186; 1000 m, on *Pinus,* 13.IX.1991 NH 12250. **Turkey.** Trabzon, 1600 m, on *Picea,* 02—04.X.1989 NH 11299, 11298.

6. ***Peniophora nuda*** (Fr.) Bres.

Reported by Hallenberg (1981) on fallen branches in N Iran. In the Caucasus by Mukhamedshin (1992) on *Fagus* and *Carpinus* in all four vegetation belts (650–1650 m) in NW Caucasus. It also occurs in Abkhasia Autonomous Republic, Akhmeta, and Gardabani, Georgia (Gvritishvili et al. 2007).

Our material is from hardwood branches in deciduous or mixed forests: NW Iran on bark of fallen hardwood branch, with *Stereum hirsutum*, Russian Caucasus on branch of *Fagus* in a riverside forest and on *Carpinus* branch in mixed forest, Turkey on an unidentified hardwood branch in a mixed forest.

Known from all continents, preferably on angiosperms, a few times on *Juniperus* (e.g. Ginns & Lefebvre 1993, García-Manjón & Moreno 1981).

Specimens examined — **Iran.** Loc. (1), on hardwood branch, 29.IX.2006 MG 304. **Russia.** Krasnodar, Mostovskoj, on *Fagus*, 06.IX.1991 NH 11995; Umpyr, 1000 m, on *Carpinus*, 07.IX.1991 NH 12003 (*P. nuda* s.l.). **Turkey.** Trabzon, 1000–1400 m, on hardwood branch, 02—12.X.1989 NH 11591.

7. ***Peniophora violaceolivida*** (Sommerf.) Massee

Reported by Hallenberg (1981) on fallen branches and twigs in N Iran. On *Carpinus* and *Vaccinium arctostaphylos* in all four vegetation belts (650–1650 m) in NW Caucasus (see Mukhamedshin 1992).

A species with a wide distribution, preferably on deciduous trees, seldom on conifers (e.g. Ginns & Lefebvre 1993).

Specimen examined — **Iran.** Loc. (2) on fallen stump of *Populus* sp., 30.IX.2006 MG 358.

8. ***Terana caerulea*** (Lam.) Kuntze

≡*Pulcherricium caeruleum* (Lam.) Parmasto

In Iran, earlier found only once on a fallen log of *Quercus castaneifolia* (Hallenberg 1981). In Abkhasia Autonomous Republic, Georgia (Gvritishvili et al. 2007), Armenia (Melik-Hačatryan 1971), on *Corylus* and *Quercus* in Ordu, Turkey (Dogan et al. 2005).

Newly collected in NW Iran on bark of moderately decayed, dead hanging branches of *Carpinus betulus* and *Cornus mas.*

More or less with a wide distribution range (apparently not reported in S America), in sites with warm and humid (micro) climate. Always found on hardwoods.

Specimens examined — **Iran.** Loc. (9), on *Carpinus betulus*, 06.X.2006 MG 469 and on *Cornus mas*, MG 474.

9. ***Tubulicrinis incrassatus*** Hallenb.

Described from N Iran by Hallenberg (1978) on fallen branches of deciduous tree in a closed forest consisting of *Parrotia persica, Carpinus betulus, Quercus castaneifolia* and *Acer.* In NW Iran on fallen branch of *Juniperus* with advanced brown rot, in a dry and rather dense *Juniperus* shrubland.

In Iran, *T. incrassatus* is known from different types of vegetation, on hardwood and on conifer. According to Hjortstam et al. (1988), it was collected in the southern part of Italy. Hjortstam & Ryvarden (2007b) report *Tubulicrinis* cf. *incrassatus* from Venezuela.

SPECIMEN EXAMINED — **Iran.** Loc. (3), on *Juniperus,* 01.X.2006 MG 365.

10. ***Xenasma pruinosum*** (Pat.) Donk FIG. 15

Two collections were made by Hallenberg (1981) in N Iran on a fallen branch of *Parrotia persica* and an unknown tree.

Known from all continents but Australia. Often on decayed deciduous trees.

SPECIMEN EXAMINED — **Iran.** Loc. (4), on decayed stump of hardwood, with *Peniophorella praetermissa,* 02.X.2006 MG 380a.

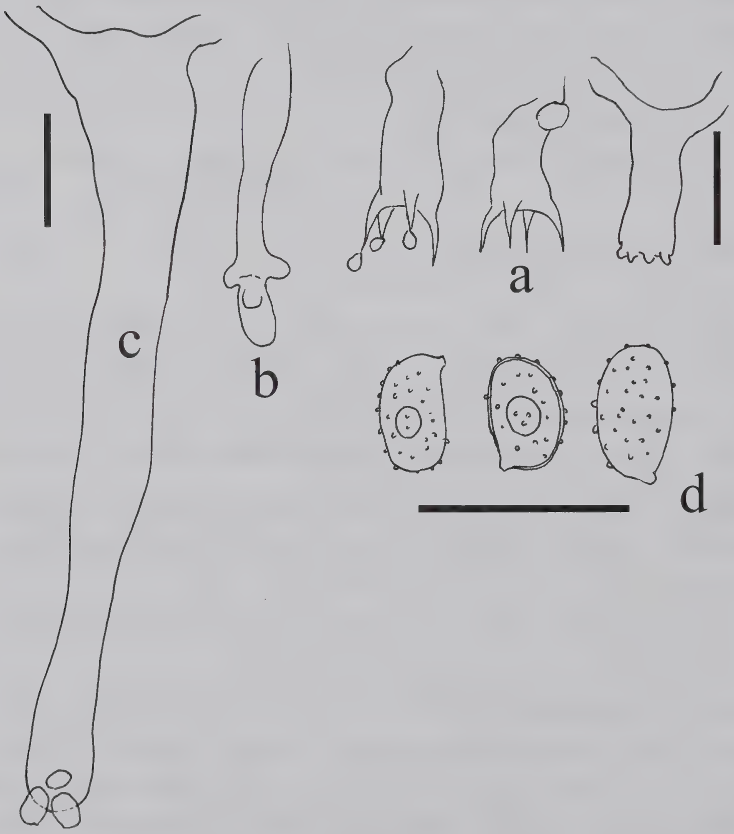


Fig. 15. *Xenasma pruinosum.*
a) Basidia, b) cystidiole with apical protuberances, c) cystidium, d) basidiospores. MG 380a.
Scale bar=10 µm.

Remarks

About 170 species of corticioids are known from Iran. Indeed this figure comes out of few inventories in the northern forest belt of the country, and therefore is far from complete. Any conclusion on the species composition of the country will be premature. Even the species mentioned in the second part of this paper may proven to be more abundant if searched for. In fact many of them are globally widely distributed. Representatives of the two genera *Aleurodiscus* s.l. and *Amylostereum* are reported for the first time from Iran. The known distribution of *Tubulicrinis incrassatus* is apparently confined to Iran and Italy.

Acknowledgments

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Entoloma reinwaldii, a rare species new to Croatia

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Abstract — *Entoloma reinwaldii* is recorded as new to Croatian mycobiota and described. The description is accompanied by black and white photographs of fresh basidiocarps and microscopic characters.

Key words — *Entolomataceae*, *Agaricales*, taxonomy, biodiversity, biogeography

Introduction

During the research of rockrose garigue (*Cistus* spp.) mycobiota in Mediterranean part of Croatia in 2000, we found two collections of beautiful pink-colored species of *Entoloma* (Fr.) P. Kumm. After microscopic examination and consultation of the literature it became clear that our collections belonged to a then undescribed species of subgenus *Leptonia* (Fr.) Noordel., section *Cyanula* (Romagn.) Noordel. Soon after that, Noordeloos & Hausknecht (2001) described this species as new, under the name *Entoloma reinwaldii*, from a similar Mediterranean habitat in Italy.

Materials and methods

Our study of *Entoloma reinwaldii* is based on two collections consisting of nine basidiocarps. The photograph of basidiocarps was taken in the field. The description of macroscopic characters is based on observations of fresh basidiocarps. Basidiocarps were preserved by drying. Microscopic features were observed by a light microscope (brightfield) with magnification up to 1500 × and photographed with a digital camera. The description and photographs of microscopic characters were made from rehydrated dried specimens mounted in 5% potassium hydroxide (KOH) solution. Spore measurements were made from the mounts of lamellae and based on calibrated digital photographs. One mature basidiocarp was selected from each collection and 50 randomly selected spores (100 spores in total) were measured without the apiculus. Spore measurements (length, width) are given as: (min.) stat. min.–*av.*–stat. max. (max), where "min." = minimum (lowest measured value), "stat. min." = statistical minimum (arithmetic average minus two times standard deviation), "*av.*" = arithmetic average, "stat. max." = statistical maximum (arithmetic average plus two times standard deviation), "max." = maximum (highest measured value). The range of arithmetic averages (av.) of spore measurements of each particular collection is also given. Standard deviation (SD) of spore length and width is given as: min.–total–max, where "min." = collection with lower SD value, "total" = SD value of all 100 measured spores, and "max" = collection with higher SD value. The length/width ratio of spores is given as the "Q" value (min.–av.–max.), and the range of arithmetic averages of "Q" value (Q av.) of each particular collection is also given. Both Croatian collections with accompanied data are deposited at the Croatian National Fungarium in Zagreb (CNF).

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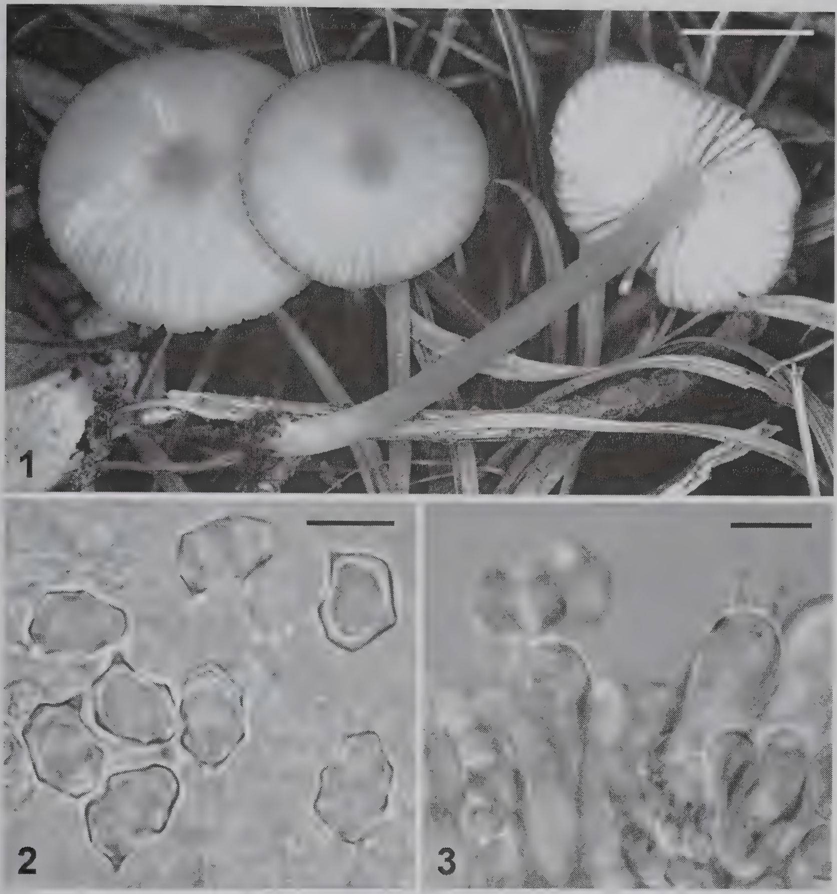
Taxonomic description

Entoloma reinwaldii Noordel. & Hauskn.,
Boll. Gruppo Micol. G. Bresadola, n.s. 43(3): 26, 2001. Figs 1–9

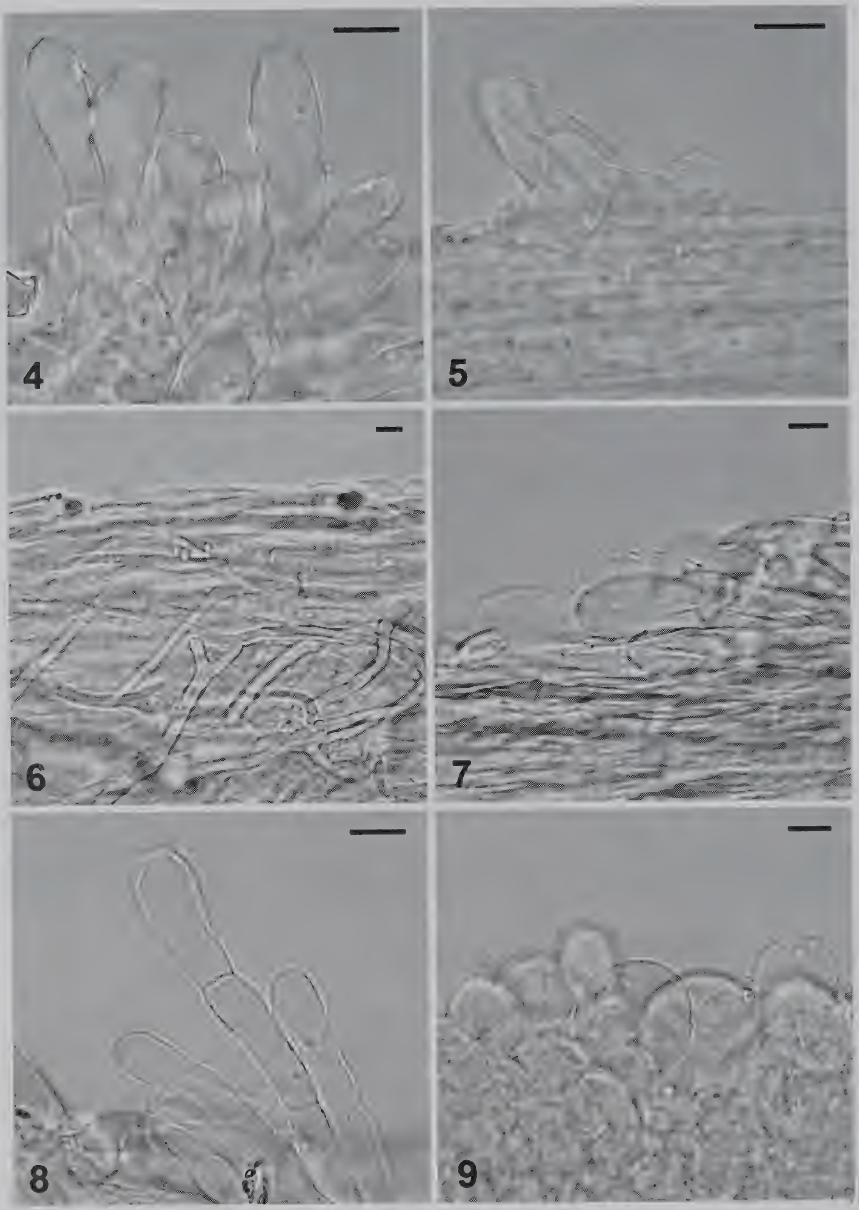
Pileus 13–22 mm broad, subhemisphaerical to truncately conical at first, later convex to plano-convex, often with applanate or depressed center, hygrophanous, pink, lilac pink, orangish pink or brownish pink when moist, pale pink on drying, more intensely colored at center, translucently striate up to 3/4 of radius, minutely squamulose, also somewhat radially fibrillose near margin, dry. Lamellae adnexed to emarginate, moderately distant to moderately crowded, whitish to pinkish (sometimes with lilac tinge) at first, then dirty pink, with entire, concolorous edge. Stipe 35–60 × 1.5–2.5 mm, subcylindrical, slightly broadened at apex, dirty pink, minutely pubescent to pruinose under a hand-lens (especially at apex), lower part often glabrous, white tomentose at base, dry, fistulose. Context whitish to pinkish. Smell weak, pleasant. Taste mild, somewhat fruity.

Spores (9.6–)10.0–*11.3*–12.5(–12.7) × (6.7–)6.8–*7.8*–8.9(–9.1) µm, av. 11.2–11.3 × 7.8–7.9 µm; SD = 0.64–*0.64*–0.64 x 0.47–*0.51*–0.55, Q = 1.22–*1.44*–1.68, Q av. = 1.43–1.45, heterodiametrical, with (5–)6–8(–9) regular to irregular angles in side view, dirty yellowish with some pink reflections in KOH (pink color more visible in water), thin-walled. Basidia 25–36 × 9–13 µm, clavate to subcylindrical, 4-spored, thin-walled, clampless. Lamellar edge sterile towards the margin of the pileus, heterogeneous towards the stipe. Cheilocystidia



Figs 1–3. *Entoloma reinwaldii.* **1.** Basidiocarps. **2.** Spores. **3.** Basidia.
Bars: 1 = 10 mm; 2 & 3 = 10 µm.

usually septate, thin-walled, hyaline, terminal elements clavate to subcylindrical, 17–61 × 6–14 µm. PLEUROCYSTIDIA absent. HYMENOPHORAL TRAMA regular, composed of 1.5–23 µm broad, thin-walled, hyaline hyphae. PILEIPELLIS a cutis (except at disc) composed of hyaline to brownish, thin-walled hyphae, with scattered bundles of repent to ascending, clavate to subcylindrical, 7–20 µm broad terminal elements; a hymeniderm to trichoderm at disc, composed of inflated elements, 23–50 × 12–28 µm; pigment intracellular. REFRACTIVE HYPHAE abundant in pileitrama, also present in hymenopodium, 2.5–8(–10) µm broad, yellowish, thin-walled. STIPITIPELLIS a cutis composed of thin-walled, hyaline hyphae, with scattered bundles of ascending, ± cylindrical elements (especially at apex of stipe). CLAMP CONNECTIONS absent.



Figs 4–9. *Entoloma reinwaldii*. **4.** Cheilocystidia. **5.** Stipitipellis. **6.** Pileipellis (cutis) and pileitrama with refractive hyphae. **7.** Bundles of repent terminal elements in pileipellis. **8.** Bundles of ascending terminal elements in pileipellis. **9.** Pileipellis at disc (hymeniderm). Bars = 10 µm.

HABITAT: Garigue with *Cistus monspeliensis, C. salviifolius, C. incanus, Erica arborea, Juniperus oxycedrus* subsp. *macrocarpa,* and *Phillyrea* sp., on soil.

> COLLECTIONS EXAMINED: CROATIA, Istria, Premantura peninsula (near the town of Pula), 44°46'07"N, 13°55'04"E, alt. 25 m, 2 December 2000, leg. Z. Tkalčec & A. Mešić (CNF 1/2111, 1/2117).

Discussion

Entoloma reinwaldii is characterized by pink basidiocarps, collybioid habit, minutely squamulose, hygrophanous, and translucently striate pileus, pileipellis a trichoderm to hymeniderm at center and a cutis with scattered bundles of repent hyphae elsewhere, absence of clamp connections, and clavate to cylindrical cheilocystidia. In the section *Cyanula,* nine more European species with pink or distinctly pink tinged pileus are known. *Entoloma catalaunicum* (Singer) Noordel., *E. queletii* (Boud.) Noordel., *E. roseotinctum* Noordel. & Liiv, *E. roseum* (Longyear) Hesler, and *E. rufocarneum* (Berk.) Noordel. can be differentiated from *E. reinwaldii* by their not hygrophanous and not (or hardly) translucently striate pileus. *Entoloma ianthinum* (Romagn. & J. Favre) Noordel. differs by complete absence of cheilocystidia, *E. ursulae* Noordel. et al. differs by dark blue stipe, *E. callirhodon* Hauskn. & Noordel. differs by darker (reddish lilaceous), fimbriate lamellar edge, and *E. cyanulum* var. *roseolum* Noordel. & Sullock-Enzlin differs by somewhat larger spores, papillate pileus, and smaller basidiocarps. Descriptions and illustrations of these species can be found in Noordeloos (1992, 2004).

Entoloma reinwaldii is a rare species. According to our knowledge, hitherto it has been found in four European countries: Italy (Noordeloos & Hausknecht 2001), France (Lejeune 2001), Spain (Vila & Caballero 2007), and Croatia. In each of these countries, the species is known from only one locality. In Italy, it was found on 19 and 21 November 1997 (two records), in province of Foggia, Mattinata, Tratturita, in Mediterranean macchia of *Pistacia lentiscus, Cistus monspeliensis, Quercus coccifera,* and *Q. ilex.* In France, it was found on 10 September 2000, in Robertsau forest at the periphery of Strasbourg, in a forest of *Populus* sp., *Acer* sp., and *Corylus* sp. In Spain, it was found on 7 October 2006, in Serra d'Heures, Sant Hilari Sacalm (Girona), in a forest of *Corylus avellana, Quercus pubescens, Fagus sylvatica* and *Fraxinus* sp. It can be concluded that *Entoloma reinwaldii* lives in different types of habitats with wood or shrub vegetation, in Mediterranean and continental climates.

Our collections show some differences compared to collections described in the literature. (i) Lilac tinges in the pileus, which are present in some basidiocarps of our collections, are not mentioned by any other author. Moreover, in his dichotomous key Noordeloos (2004: 814, 815) emphasized that the pileus of

Entoloma reinwaldii has no lilaceous tinge. (ii) In our collections lamellae are adnexed to emarginate, while in the other descriptions lamellae are said to be more variable and also can vary from adnate to (sub)decurrent. (iii) Spores in the French collection (Lejeune 2001) are slightly shorter ([8.8–]10–11.2 × 8 µm). (iv) Noordeloos & Hausknecht (2001) and Lejeune (2001) described lamellar edge as completely sterile, while basidiocarps in our collections have sterile (towards the margin of the pileus) to heterogeneous (towards the stipe) lamellar edges. The collection of Vila & Caballero (2007) also shows variability of lamellar edge, where cheilocystidia are abundant in some basidiocarps and absent in others. (v) All authors described pileipellis at the center of pileus as a trichoderm, while basidiocarps in our collections have a hymeniderm to trichoderm with more inflated elements. (vi) Our collections have abundant refractive hyphae in pileal trama (also present in the hymenopodium), which is not mentioned by the other authors.

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Studies in the genus *Entoloma* (*Basidiomycota*, *Agaricales*) from the Kiklades (C. Aegean, Greece)

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Abstract—An intensive mycological inventory of the Greek Kiklades Islands yielded a number of interesting records, two of them being new to science: *Entoloma leuconitens* and *E. alnicola*. Descriptions are given of another eight taxa new to the Greek mycoflora, among them the extremely rare *Entoloma nigroviolaceum*, *E. griseopruinatum*, and *E. griseorugulosum*.

Key words—new species and records, agarics, *Entolomataceae*

Introduction

Reports on the macrofungi from the islands of the Aegean archipelagos are scarce in literature (Petrak 1943a,b, Plank 1980). In the frame of an ongoing inventory of the Greek macrofungi (Dimou et al., 2008; Zervakis et al., 2004), the islands of Kiklades (C. Aegean, Greece) Andros, Naxos and Amorgos have been thoroughly investigated. In the recent past, Andros has been visited periodically by P. Lizoň (1993-1997), and from 1995 until present by E. Polemis, who is conducting a year-by-year inventory (mainly from September to March). Some preliminary results of this work, including several records new for Greece, were presented in national check-lists (Zervakis et al., 1998; 1999) and during scientific conferences (Polemis et al., 2002; 2007). Recently, two new species of *Gymnopus* were described from the island of Andros (Polemis & Noordeloos, 2007).

The genus *Entoloma* has been studied by the first author on a worldwide scale (Gates & Noordeloos 2007, Manimohan et al. 2006, Noordeloos 1981, 1987, 1992, 2004, 2006, 2007). However, data are still lacking on occurrence and distribution of many species in Southern Europe, in particularly from the Eastern Mediterranean region (Balkans, Greece). To date, the biodiversity of this major agaricoid genus, is very basically known in Greece, as only a limited number of taxa (less than 30 in total), if compared with other European countries, are recorded. This paper presents two new species from the Kiklades, and describes another five rare, as well as three more widespread and common European taxa, that so far had not been recorded from Greece.

Taxonomic part

1. New taxa

Entoloma leuconitens Noordel. & Polemis, **sp. nov.** **Fig. 1**

MycoBank mb 512002

Pileus c 20 mm latus, conicus, haud hygrophanus, paulisper translucido-striatus, albus, glaber, sericeus. Lamellae subliberae, roseae. Stipes 20 × 2 mm, albus, politus. Odore saporeque rancidis. Sporae (9–)9.5–12(–15) × (6.5–)7.5–9 µm, 6–8-angulatae. Acies lamellarum sterilis. Cheiloystidia 15–45 × 7–15 µm, utriformia. Pileipellis cutis hyphis cylindraceis, 2–6(–8) µm latis, pigmentis intracellulosis. Fibulae praesentes. Ad terram acidam. Holotypus: Greece, Isl. Andros, Kiklades (C. Aegean), Torna, 29 Oct. 2002, E. Polemis 02-A472 (L)

Etymology—*leucos* = white; *nitens* = shining.

Description—Pileus 20 mm, conical, with slightly inflexed, undulating margin, not hygrophanous, faintly translucently striate at the extreme margin only, white to creamy, ivory, glabrous with a lustrous appearance. Lamellae moderately distant, adnate to almost free (adnexed), white then pinkish, with concolourous edge. Stipe 20 × 4 mm, cylindrical, slightly broadened towards base, curved, white to creamy, smooth, glabrous, polished to faintly fibrillose striate, brittle. Context thin, brittle, white, smell and taste rancid.

Spores (9–)9.5–12(–15) × (6.5–)7.5–9 µm, Q = 1.2–1.5(–1.8), heterodiametrical, with 6–8 rather irregular angles. Basidia 30–40 × 11–13 µm, 4-spored. Lamellae edge sterile. Cheilocystidia 15–45 × 7–15 µm, mostly utriform, to cylindrical-clavate. Pleurocystidia absent. Pileipellis a thin cutis made up of cylindrical, 2–6(–8) µm wide hyphae. Pigment very faint, probably intracellular. Clamps present in hymenium, not seen elsewhere.

Habitat: In acidic soil in mountain heath-land with *Erica arborea*, and *Pteridium aquilinum* and with scattered trees like *Fraxinus* sp., *Crataegus monogyna* and *Pyrus amygdaliformis*, on soil among *P. aquilinum*.

Collection examined: Greece, Isl. Andros, Kiklades (C. Aegean), Torna, 29 Oct. 2002, E. Polemis 02-A472 (L, holotype).

The white, non-hygrophanous, lustrous pileus, elongate, rather irregularly shaped spores, and sterile lamella edge with utriform cheilocystidia are distinctive for this species. *Entoloma pallideradicatum* Hauskn. & Noordel. is

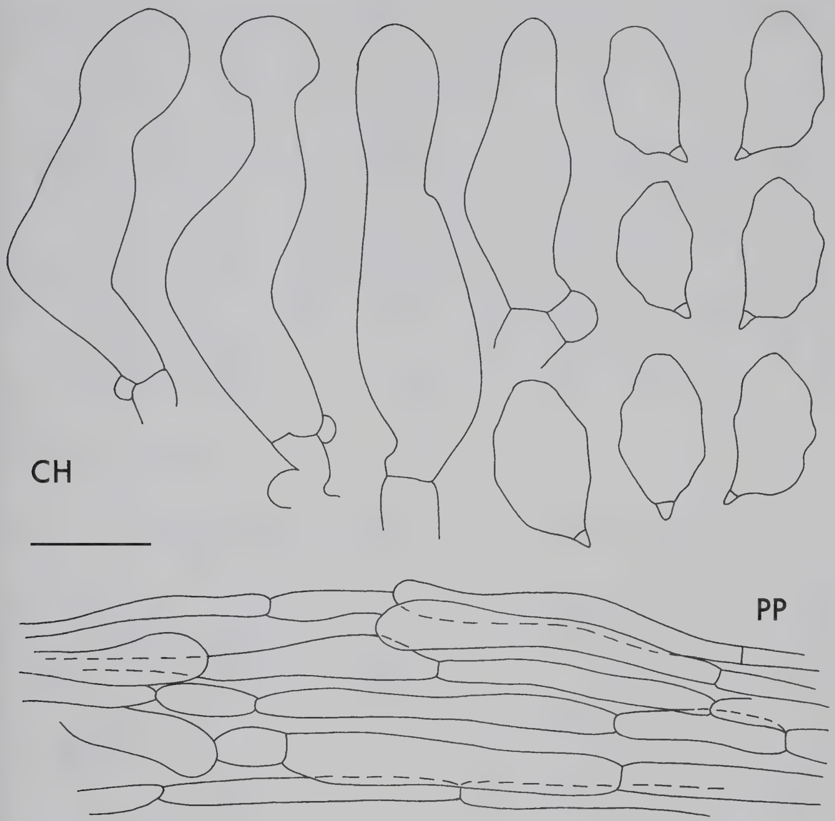


Fig. 1. *Entoloma leuconitens*. Spores, cheilocystidia (CH), and pileipellis (PP). Bar = 10 µm.

close, but differs in slightly smaller spores, heterogeneous lamella edge, and lack of clamp-connections.

Entoloma alnicola Noordel. & Polemis, **sp. nov.** **Fig. 2.**

MycoBank mb 512003

Pileus 13–20 mm latus, convexus demum applanatus, hygrophanus, translucido-striatus, obscure griso-brunneus, pallescens, minute fibrillosus. Lamellae adnatae, roseae. Stipes 20–30 × 2 mm, griseo-brunneus, fibrilloso-striatus, ad apicem fibrillosus. Odore saporeque haud notatis. Sporae (7.5–)8.5–10.5(–11.5) × 6.5–8 µm, 5–6(–7) angulatae. Acies lamellarum sterilis. Cheilocystidia 15–45 × 6.5–17 µm, clavata, cylindracea vel utriformia. Pileipellis trichoderma hyphis inflatis ad 30 µm latis, pigmentis intracellulosis. Fibulae absentes. At terram in alnetum. Holotypus: Greece, Isl. Andros, Kiklades (C. Aegean), Torna, 22 Sep. 2002, E. Polemis 02-A364 (L; isotype LGAM-AUA)

Etymology: *alnicola* = associated with *Alnus*.

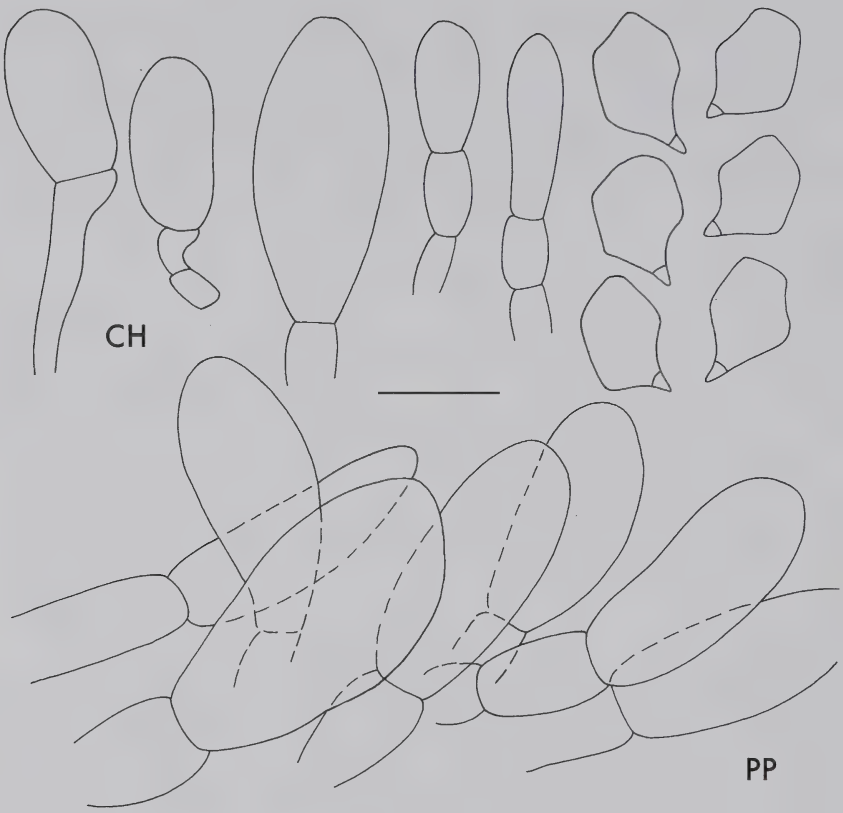


Fig. 2. *Entoloma alnicola.* Spores, cheilocystidia (CH), and pileipellis (PP). Bar = 10 µm.

Description—Pileus 13–20 mm, finally planocovex to aplanate, hygrophanous, translucently striate, dark grey-brown at disk and striae, fading to sordid brown towards the margin, which is finally straight and slightly undulating, minutely fibrillose-squamulose. Lamellae moderately distant, adnate, white to pinkish, with concolorous edge. Stipe up to 20–30 × 2 mm, cylindrical, greyish-beige at apex, darker grey-brown at base, fibrillose striate, pruinose at apex. Smell and taste not recorded.

Spores (7.5–)8.5–10.5(–11.5) × 6.5–8 µm, Q = 1.2–1.4(–1.5), heterodiametrical, with 5–6(–7) pronounced angles, relatively thick-walled. Basidia (1)2-spored. Lamellae edge sterile. Cheilocystidia 15–45 × 6.5–17 µm, broadly clavate to cylindrical, utriform. Pileipellis a trichoderm with inflated, clavate terminal elements, up to 30 µm broad. Brilliant granules present. Pigment brown, intracellular. Clamps absent.

Habitat: Saprotrophic on wet mossy soil with woody residues of *Alnus glutinosa* along a stream with *Platanus orientalis*, and *Alnus glutinosa*.

> Collection examined: Greece, Isl. Andros, Kiklades (C. Aegean), Torna, 22 Sept. 2002, E. Polemis 02-A364 (L, holotype).

Entoloma alnicola belongs to subgenus *Cyanula*, stirps *Longistriatum*, close to *E. longistriatum* (Peck) Noordel., from which it differs, however, by the rather dark grey-brown tinges in pileus and stipe, a fibrillose-striate stipe surface, the 2-spored basidia and the predominantly utriform or broadly clavate cheilocystidia. *Entoloma turci* (Bres.) M.M. Moser, which is similarly grey-brown, has a less distinct, non-translucently striate pileus, polished stipe, which frequently turns reddish at the base, 4-spored basidia and differently shaped cheilocystidia. *Entoloma scabropelle* Noordel. has a fertile lamella edge, and 4-spored basidia.

2. New Greek records

Entoloma nigroviolaceum (P.D. Orton) Hesler, Persoonia 11(4): 471 (1967)

Description—Pileus 10–35 mm, hemispherical to convex, irregularly convex, flat at centre, margin involute and often undulate, not translucently striate, not hygrophanous, initially dark violaceous-black, then vinaceous-grey, at first, innately fibrillose-tomentose to rugulose at centre, then entirely tomentose, radially fibrillose to squamulose at centre. Lamellae moderately distant, adnate, whitish to grey-bluish (lead-grey), then pinkish with concolorous edge. Stipe 30–50 × 2–6 mm, cylindrical to compressed, grey-blue to violaceous-grey, fibrillose-striate, initially whitish tomentose towards the base, pruinose at apex, becoming smooth with age. Context pale blue-violaceous, Smell absent, weak.

Spores (9–)9.5–13 × 7–9 µm, Q = 1.2–1.5, irregularly 5–8 angled in side view. Basidia (2)4-spored. Lamellae edge fertile. Cystidia absent. Pilepellis a transition between a cutis at margin and a trichoderm towards the centre, made up of inflated terminal elements up to 25 µm broad, some apically or laterally rostrate, pigment grey to violaceous-brown, intracellular. Clamps absent.

Habitat: Mountain acidic heath land with *Erica arborea*, *Genista acanthoclada*, *Crataegus monogyna*, and *Pteridium aquilinum*, on wet mossy soil.

> Collection examined. Greece, Isl. Andros, Kiklades (C. Aegean), Vourkoti, 8 Oct. 2002, E. Polemis 02-A414.

Entoloma nigroviolaceum is a striking species with dark violaceous-black basidiocarps, and large, many-angled spores. It is a very rare species, known from only few records in Northwestern Europe (Noordeloos 2004). In all cases it has been found on fairly poor, acid peaty soil with mosses and *Sphagnum*. It has never been recorded so far from Greece. *Entoloma nigroviolaceum* belongs to a small group of closely related species, all of them being rare and indicative of very special habitat conditions.

Entoloma griseopruinatum Noordel. & Cheype, Fungi Europaei, 5a: 876 (2004)

Description—Pileus 40–60 mm, planoconvex, finally somewhat depressed at centre, with a small umbo and deflexed, straight to undulating margin, not hygrophanous, not or slightly translucently striate, dark grey-brown, radially innately fibrillose, with a greyish pruina left at the centre of pileus. Lamellae moderately distant, adnate-emarginate, grey-beige with a pink tinge, with concolourous or slightly paler edge. Stipe 40–60 × 7–15 mm, cylindrical to somewhat compressed, base somewhat rooted, concolorous with pileus, with white fibrillose covering, pruinose at apex, whitish and almost smooth at base. Context thick and firm, grey. Smell and taste strongly farinaceous.

Spores 8.5–11(–12.5) × 7–10 µm, Q = 1.0–1.3, almost isodiametrical, rather obtusely angled. Basidia 4-spored. Lamellae edge fertile. Cystidia absent. Pileipellis cutis of cylindrical hyphae, 4–13 µm broad, pileitrama made of inflated elements up to 22 µm broad. Pigment yellow-brown intracellular. Clamps abundant in all tissues.

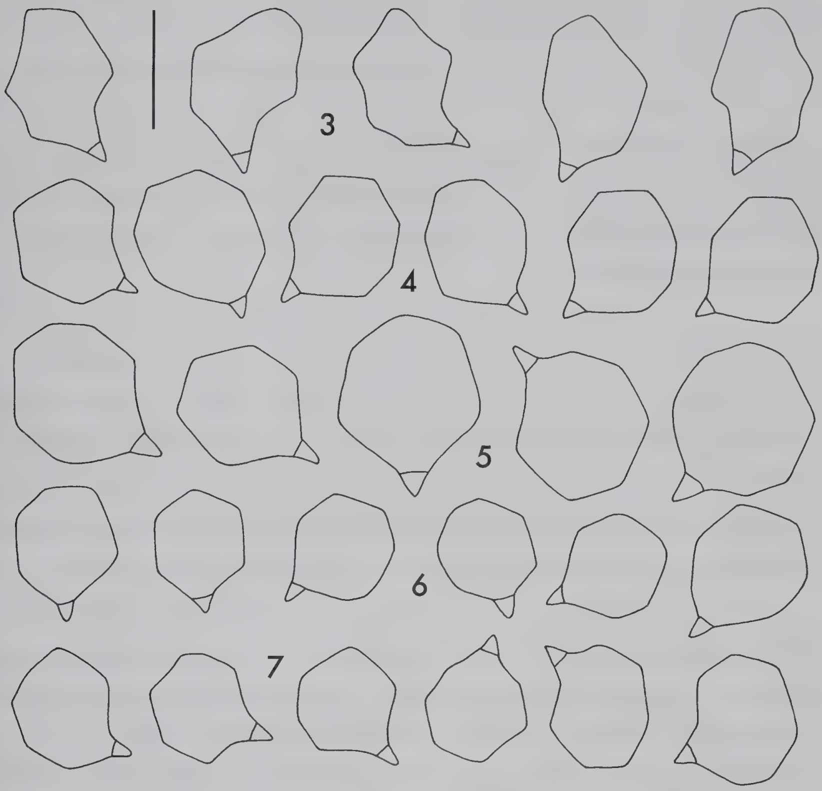
Habitat: In dry heath land with various Mediterranean spiny scrubs (*Phrygana*), on soil among *Sarcopoterium spinosum* scrubs.

Collection examined: Greece, Isl. Amorgos, Kiklades (C. Aegean), Theologos Monastery, 4 Dec. 2005, E. Polemis 05-M199.

Entoloma griseopruinatum is a very distinct species in stirps *Lividoalbum* in subgenus *Entoloma* with relatively stout, firm basidiocarps. The dark colours, non-hygrophanous, and pruinose pileus are distinctive (Noordeloos 2004). So far it was known only from the type locality in France, Haute Savoie, where it was found growing in a mountainous *Fagus* wood, a habitat very different from the Greek location, which represents the second known locality of this rare species. The type collection showed a distinct yellow tinge at the base of the stipe, which has not been observed in the Greek material. Recently, it has been recorded from two localities in Spain (Girona), in montane mixed broadleaved forests of *Corylus avellana, Betula pendula, Fraxinus excelsior, Salix caprea* and *Sorbus aria* (Vila & Caballero 2007). *Entoloma griseorugulosum* is somewhat similar, differing, however, by a more fibrillose-rugulose pileal surface, and the presence of incrusting pigment in the pileipellis (see below).

Entoloma griseorugulosum Noordel. & Fern. Sas. Fungi Europaei, 5a: 872 (2004)

Description—Pileus 30–40 mm, convex then applanate with low umbo, margin involute then straight, slightly lobed, not hygrophanous, not translucently striate, dark grey-black to drab-sepia, becoming at centre smoke to mouse-grey, silky, innately fibrous. Lamellae moderately distant, adnate, moderately



Figs. 3-7. Spores.
3. *E. nigroviolaceum*. 4. *E. griseopruinatum*. 5. *E. griseorugulosum*.
6. *E. juncinum*. 7. *E. sordidulum*. Bar = 10 µm.

thick, smoke-grey to milky-coffee, with concolourous edge. Stipe up to 50 × 10–20 mm, ventricose, with somewhat rooting base, whitish-greyish, coarsely fibrillose lengthwise, pruinose at apex, at base white tomentose, compact and firm, with white rhizomorphs. Context brittle, grey, smell and taste distinctly farinaceous.

Spores (9–)10–14(–17) × (8–)9.5–13.5(–15) µm, Q = 1–1.2, subisodiametrical, with 6–8 obtuse to pronounced angles, moderately thick walled. Basidia 55–74 × 13–17 µm, (2–)4-spored. Lamellae trama made up of cylindrical hyphae, mostly longer than 100 µm, with pustulate wall-surface. Lamellae edge fertile. Cystidia absent. Pileipellis a cutis of long cylindrical, 3–8 µm wide hyphae. Pileitrama densely packed, made up of short inflated elements, in chains. Pigment intracellular, and additionally incrusting in the narrow hyphae of pileipellis and subpellis. Clamps abundant in all tissues.

Habitat: In calcareous *Quercus ilex* stand, on rich humus mixed with excessive amounts of goat dung under *Q. ilex*.

Collection examined: Greece, Isl. Naxos, Kiklades (C. Aegean), Kinidaros, 12 Dec. 2004, E. Polemis 04-N207.

Entoloma griseorugulosum was described from a thermophilic *Quercus* wood in the Basque country, northern part of the Iberian peninsula, and is very distinctive on account of its very dark basidiocarps, non-hygrophanous, strong farinaceous smell, fibrous pileus and fibrous stipe surface, and two types of pigment in the pileipellis.

Entoloma juncinum (Kühner & Romagn.) Noordel., Persoonia 10: 255 (1979)

Description—Pileus 20–40 mm, convex, soon plano-convex, obtuse, margin slightly involute at first, but soon straight, slightly undulating, hygrophanous, when wet dark brown at disc and striae, grey to milky-coffee towards the margin, striate from the half radius up to disc, fading to yellowish-brown, surface smooth, silky. Lamellae emarginated to almost free, beige then greyish-pink. Stipe 60–70 × 2–5(–7) mm, cylindrical, compressed, broadened towards the base, concolorous with pileus, smooth and polished, apex pruinose.

Spores 7.5–10.5(–11) × 7–9(–10) µm, Q = 1–1.2, almost isodiametrical, 5–7 angled. Basidia 32–42 × 10–13 µm, 4-spored. Lamellae edge fertile. Cystidia absent. Pileipellis cutis of cylindrical hyphae, to 12 µm broad, with incrusting yellow-brown pigment. Pileitrama made of inflated cells to 25 µm broad, with incrusted walls. Clamps present in hymenium, not seen elsewhere.

Habitat: In a moist thicket by a stream, on humus-rich soil under *Quercus pubescens*, *Platanus orientalis* and *Alnus glutinosa* (A361). Also in mountain acidic heath land with *Erica arborea*, *Genista acanthoclada*, *Crataegus monogyna*, and *Pteridium aquilinum*, on wet humus-rich, mossy soil (A413).

Collections examined. Greece, Isl. Andros, Kiklades (C. Aegean), Evrousses, 22 Sept. 2002, E. Polemis 02-A361. Greece, Isl. Andros, Kiklades (C. Aegean), Vourkoti, 8 Oct. 2002, E. Polemis 02-A413.

Entoloma juncinum is a species with a very wide distribution, preferring damp places in mixed forest on rather damp soil, but frequently also found in grassland, where it can be confused with slender forms of *Entoloma sericeum* Quél. (Noordeloos 2004).

Entoloma sordidulum (Kühner & Romagn.) P.D. Orton, Trans. Br. Mycol. Soc. 43: 175 (1960)

Description—Pileus 2.5–4 cm, almost conical, with undulating margin, slightly hygrophanous, when wet dark grey-brown, hazel at centre, olivaceous-buff at margin, indistinctly translucently striate at extreme margin only, drying to buff, surface smooth, innately fibrillose. Lamellae emarginate, greyish, then vinaceous-buff to clay-pink, with smooth concolorous edge. Stipe 3–5 × 0.5–0.6 mm, cylindrical, greyish-brown smooth, silky-polished to indistinctly striate. Context greyish-white, firm. Smell and taste rancid.

Spores 7–11(–12) × (7–)7.5–8.5(–9) µm, Q=1.0–1.3, almost isodiametrical, rather pronouncedly 5–6-angled in side-view. Basidia 4-spored. Lamellae edge fertile. Cystidia absent. Pileipellis cutis of cylindrical hyphae, 3–10 µm broad, with minute to coarse incrusting and additionally some intracellular yellow-brown pigment. Clamps rare in pileipellis, frequent in hymenium.

Habitat: In thicket, on humus-rich soil under *Quercus pubescens*.

Collection examined: Greece, Isl. Andros, Kiklades (C. Aegean), Falika, 10 Oct. 2002, E. Polemis 02-A430.

Entoloma sordidulum is a widespread and common species, particularly in deciduous and mixed forest on rich soil in North-western Europe (Noordeloos 2004). However, records from the Mediterranean are scarce. It is distinctive with its relatively small and slender basidiocarps, dull brown colour, and predominantly incrusting pigment in the pileipellis. It belongs to a group of rather similar species in section *Rhodopolia*, which may be all mycorrhizal, and difficult to distinguish.

Entoloma lividoalbum (Kühner & Romagn.) Kubička, Česká Mykol. 29: 27 (1975)

Description—Pileus 90–110 mm, convex, then plano-convex with a blunt but distinct umbo, finally applanate to somewhat depressed, margin at first inflexed then straight and irregularly undulating, hygrophanous, indistinctly translucently striate at the extreme margin, dark brown fading to light greyish-beige, smooth, glabrous, with silky appearance. Lamellae moderately crowded, emarginate, ventricose, white then clay-pink, with concolorous edge. Stipe 70–80(–90) × 10–20(–30) mm, cylindrical, attenuates towards the base, whitish, fibrillose-striate lengthwise. Context thick, firm, white. Smell and taste farinaceous.

Spores 9–11(–13) × 8–9(–11) µm, Q=1.1–1.3, 5–7 angled, subisodiametrical. Basidia 37–45 × 11–14 µm, (2)4-spored. Lamella edge fertile. Cystidia absent. Pileipellis an (ixo)cutis of narrow cylindrical hyphae. Pigment brown, intracellular. Clamps abundant in all tissues.

Habitat: In a thicket, on humus-rich soil under *Quercus pubescens*.

Collection examined: Greece, Isl. Andros, Kiklades (C. Aegean), Agios Spyridon, 20 Dec. 1997, E. Polemis 97-A178.

Entoloma lividoalbum is a widespread species in Europe, and prefers *Quercus* forest on rich soil. It is distinctive because of its relatively stout, tricholomatoid habit, smooth, medium brown, hygrophanous pileus and white stipe.

Entoloma mougeotii (Fr.) Hesler, Beih. Nova Hedwigia 23: 158 (1967)
var. **mougeotii**

Description—Pileus 15–40 mm, convex with involute margin, slightly umbilicate, expanding to applanate, with straight margin, not hygrophanous, not translucently striate, initially dark violaceous-black, then dark grey, violaceous-brown, uniformly coloured, or more often darker at the centre, entirely tomentose to minutely squamulose, somewhat rimose-fissurate when old. Lamellae adnate, or with a decurrent tooth, white then pink, with concolorous, fimbriate margin. Stipe 20–60 × 1–4 mm, cylindrical to slightly compressed, with longitudinally groove, steel-grey, at first longitudinally fibrillose, then smooth shiny, white tomentose at base. Context thin, fragile at stipe, easily splitting lengthwise. Smell indistinct and taste not recorded.

Spores (8.5–)9–11.5(–12) × 6–8 µm, Q = 1.2–1.6, heterodiametrical, with 5–8 pronounced angles. Basidia 27–48 x 10–14 µm, 4-spored. Lamella edge sterile. Cheilocystidia 16–60(–80) × 7–17 µm, cylindrical to slenderly clavate. Pileipellis a trichoderm, made up of inflated cylindrical to clavate, or utriform terminal elements, 6–25 µm wide. Pigment violaceous-brown, intracellular. Clamps absent from all tissues.

Habitat: Along a river's bank, on humus-rich soil under *Platanus orientalis* and *Alnus glutinosa* (A446). On grassy soil, in field with *Olea europaea* and *Cupressus sempervirens.*

Collections examined: Greece, Isl. Andros, Kiklades (C. Aegean), Achlas River, 11 Oct. 2002, E. Polemis 02-A446. Greece, Isl. Andros, Kiklades (C. Aegean), Ypsilou, 28 Nov. 2002, E. Polemis 02-A618.

Entoloma mougeotii is distinctive because of its delicate violaceous-brown colour and sterile lamella edge with large cheilocystidia. It has a wide distribution all over Europe, but only in very special grassland habitats, for which it is a good indicator species (Vesterholt 2002).

Entoloma cruentatum (Quél.) Noordel., Persoonia 12: 201. 1984.

Description—Pileus 20–50 mm, hemispherical, strongly umbilicate, with straight margin, expanding to convex, depressed, not hygrophanous, translucently striate to the half of radius, more evidently as the pileus expands, dark bluish to greyish black, at first uniformly coloured, then only at centre and striae, with the rest of the surface greyish, smooth and silky, somewhat rugulose and then adpressedly fibrillose at centre. Lamellae moderately distant, adnate, greyish-blue, with concolorous margin. Stipe 30–50 × 2–3 mm, cylindrical to slightly enlarged at base, concolorous with pileus, or somewhat paler, smooth, polished, white tomentose at base.

Spores 9–12 × 7–9 µm, Q = 1.3–1.5, heterodiametrical, with 6–8 pronounced angles. Basidia 30–45 × 10–12 µm, 4-spored. Lamella edge fertile. Cheilocystidia absent. Pileipellis a trichoderm transiting to cutis towards the margin, made up of inflated cylindrical to clavate, or utriform terminal elements, 7–20(–30) μm wide. Pigment brown, intracellular. Clamps absent from all tissues.

HABITAT: In an open meadow with *Olea europaea* trees, on grassy soil.

> COLLECTION EXAMINED: Greece, Isl. Andros, Kiklades (C. Aegean), Ypsilou, 15 Dec. 2007, E. Polemis 07-A906.

Entoloma cruentatum is very close to *E. chalybeum*, from which it mainly differs by the fertile lamella edge without cheilocystidia. Usually a distinct orange coloured mycelium has been observed at the base of the stipe, but this seems to be absent in the Greek material. *Entoloma cruentatum* is a very rare species, recorded so far from North-western Europe where it is a good indicator species for old, poorly manured grasslands. It figures on the Red Data lists of Denmark, Norway and Schleswig-Holstein (Vesterholt 2002). It has not been recorded from the Mediterranean so far. A strongly umbilicate pileus, such as in our specimens, has not been recorded for this species in pertinent descriptions.

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A new species of *Dactylellina* producing adhesive knobs and non-constricting rings to capture nematodes

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Abstract — A nematode-trapping fungus, *Dactylellina daliensis*, is illustrated and described as a new species. This fungus is primarily characterized by producing elongate fusoid conidia with 1-13 (mostly 6-8) septa on the denticles of conidiophore and capturing nematodes by means of stalked adhesive knobs and non-constricting rings.

Key words — Antagonist of parasitic nematodes, predacious fungi, biological control, trapping devices

Introduction

Nematode-trapping fungi are a group of hyphomycetes capable of capturing, killing and digesting nematodes by special modified hyphal structures called trapping devices. As antagonists of parasitic nematodes, these fungi have been the subject of research over several decades. These fungi are abundant in many habitats examined so far, with only a few species showing restricted geographical distribution (Duddington 1951a, b; Gray 1987). During a recent survey of the nematode-trapping hyphomycetes in rhizosphere soil of pine in Yongping County, Dali Prefecture, Yunnan Province, a nematode-trapping fungus with adhesive knobs and non-constricting rings was isolated and identified. Comparing its morphological characters to the known species, and following the concept of predacious hyphomycete genera as emended by Li et al. (2005), we confirm that this species is a new one and name it as *Dactylellina daliensis.*

Materials and methods

While surveying the predacious fungi, soil samples from pine rhizosphere in Yongping County, Dali Prefecture, Yunnan Province were collected in September 2007. Subsamples of 2-5 g were spread on Corn Meal Agar (CMA) plates. After incubation at room temperature (about 20-28°C) for 10 days, conidia of nematode-trapping fungi were transferred into fresh CMA plates by sterile toothpicks to obtain pure cultures. For identification, cultures obtained were inoculated on CMA and incubated at 28°C for 14-30 days and the taxonomic characters were measured and determined. Conidial size and septate were calculated by measuring more than 100 conidia. Microscopic photographs were taken using an Olympus BX51 microscope. To induce trap formation, a 2 cm^2 piece of agar in the center of the plate was removed from a 7-day old culture to create an open space. About 200 nematodes (*Panagrellus redivivus*) were added into the free space after the mycelia emerged from the cut margin.

Taxonomic description

Dactylellina daliensis Hong Yan Su, **sp. nov.** PLATE 1

MYCOBANK MB 511994

Coloniae albae in CMA, ad 6 cm diam. post 7 dies 25 °C. Mycelii sparsa, hyphae hyalinae, septata, ramosa, 2.2-3.7 μm lata. Conidiophora erecta, hyalina, ramosa, 2-4 septata, 21-101 μm longa, 1.8-2.5 μm crassa ad basem, 1.5-1.7 μm crassa ad apicem, lata conidla greges in perspicuis dendriculis in capitata. Conidia hyalini, elongati fusiformis vel clavati, 1-13 septati, praecipue 6-8 septati, 28.7-51.5 (40.8) × 3.2-5.2 (4.2) μm.

HOLOTYPE: YMFT 1.0213, permanent slide, Yongping County, Dali Prefecture, Yunnan Province, P.R. China, HongYan Su, Sep. 2007.

ETYMOLOGY: species epithet refers to the collection site of the species.

Colonies white on CMA, growing rapidly, obtaining a diameter of 6 cm at 25°C within 7 days. Mycelium sparse, hyphae hyaline, septate, branched, 2.2-3.7 μm wide. Conidiophores erect, colorless, more or less branched, 2-4 septate, 21-101 μm high, 1.8-2.5 μm wide at the base, gradually tapering upward to a width of 1.5-1.7 μm at the tip where forming 1-7 apical conidia. Conidia hyaline, elongated fusoid-shaped or clavate, straight or somewhat curved, round at the distal end, truncate at the base, 1-13 (mainly 6-8) septate, 28.7-51.5 (40.8) × 3.2-5.2 (4.2) μm in length and width. Trapping devices, stalked adhesive knobs and non-constricting rings, forming on water agar medium when challenging with living nematodes. Chlamydospores not observed in culture.

Discussion

In the known species of nematode-trapping fungi, *Dactylellina daliensis* only resembles only three other species in the genus: *D. haptospora* (Drechsler

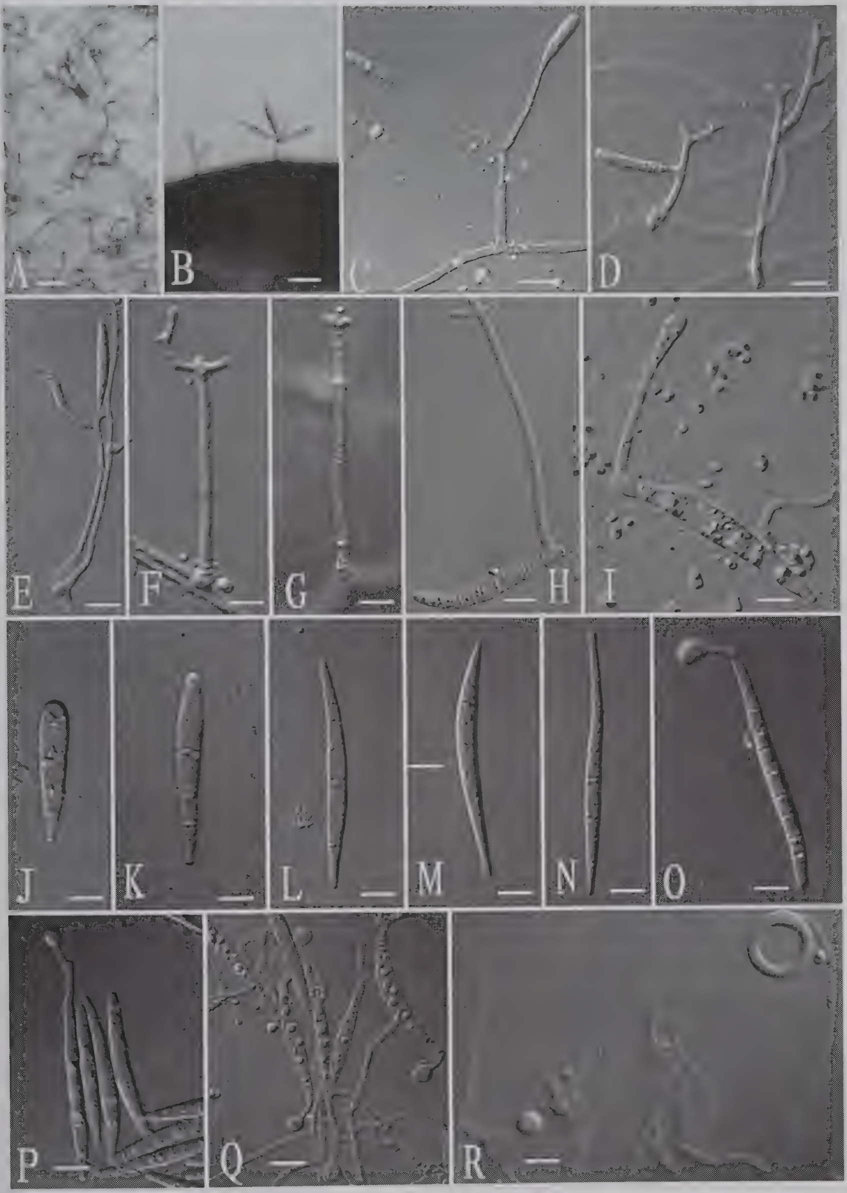

Plate 1. *Dactylellina daliensis*. A-B. Conidiophores and conidia on CMA medium. C-G. Conidiophores. H-P. Conidia. Q. Stalked knobs on conidia and mycelia. R. Non-constricting rings. Scale bars: A=50 μm, B=25μm, C, E=12.5 μm, D, F-R=5 μm.

1940), *D. leptospora* (Drechsler 1937) and *D. varietas* (Li et al. 2006). Both *D. daliensis* and *D. leptospora* produce elongated fusoid conidia and capture nematodes by the same kinds of trapping devices (stalked adhesive knobs and non-constricting rings). However, unlike *D. daliensis,* which forms terminal cluster of conidia, *D. leptospora* mainly bears a single terminal conidium, occasionally producing an additional conidium on a short branch attached to the main axis near the conidiophore apex. Furthermore, the conidial length of *D. daliensis* (28.7-51.5 µm) is shorter than that of *D. leptospora* (40-105 µm). *D. daliensis* and *D. varietas* have similar conidial shape, arrangement of conidia on conidiophores, and trapping device types, but they differ in the size of conidia, 28.7-51.5 (40.8) × 3.2-5.2 (4.2) µm for *D. daliensis* and 25-61.5 (46.5) × 6.5-10 (9) µm for *D. varietas.* Additionally, unlike *D. varietas*, conidia of *D. daliensis* can form stalked adhesive knobs on their terminal. Both *D. daliensis* and *D. haptospora* can bear terminal conidial clusters and form stalked adhesive knobs as trapping devices. However, *D. daliensis* differs from *D. haptospora* by producing an additional type of trapping device, non-constricting rings.

Acknowledgements

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Studies in *Amanita* subsection *Vittadiniae* I— a new species from Colombian savanna

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This paper is dedicated to Dr. Cornelis Bas on the occasion of his eightieth birthday.

Abstract—*Amanita savannae* is described as new from the Departamento de Meta, Colombia.

Key words—*Amanita* subsect. *Limbatulae*, *Amanita* subsect. *Solitariae*, South America, taxonomy

Introduction

Amanita savannae is a member of the growing group of apparently nonmycorrhizal, or at least not obligately mycorrhizal, species in *Amanita* subsect. *Vittadiniae* Bas. The paper of Wartchow et al. (2007) can be considered a previous work in the present series. Previous work on *Amanita* of Colombia includes (Tulloss et al. 1992). Illustrations and brief descriptions of Colombian species of *Amanita* as well as other taxa can be found in (Franco-Molano et al. 2000).

Materials and methods

Methods used are those of Bas 1969 and Tulloss et al. (1992) as modified by Tulloss (1993, 1994, 2000, 2008). Color codes of the form 4A5 follow Kornerup and Wanscher (1978). Herbarium name abbreviations are confor-

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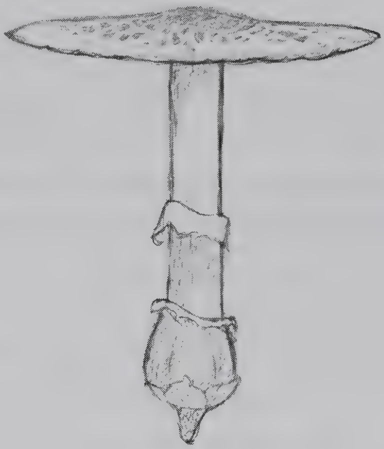

Fig. 1. *Amanita savannae* (holotype). Habit (×1.7), reconstructed from exsiccatum. Pencil sketch by Richard Rauh (NY).

mant with (Holmgren et al. 1990), with the exception of RET (Tulloss' herbarium). Abbreviations in author citations follow Kirk and Ansell (1992, 2008).

Taxonomic part

Amanita savannae Tulloss & Franco-Mol. **sp. nov.** **Fig. 1**

MYCOBANK **#** 511862

> *Pileus* 12–30 *mm latus, albus vel griseobrunneus, convexus vel planus vel concavus, squamellulis tenuibus et brunneis insidens disci. Lamellae albae. Stipes* 13–30 × 4–7 *mm, pallidus, annulo albo, membranaceo, medio vel inferiori, bulbo subnapiformi. Fibulae praesentes. Sporae subglobosae vel late ellipsoideae, amyloideae, interdum globosae, interdum elongatae,* (6.5–) 7.2–10.8 (–13.5) × (6.0–) 6.2–8.5 (–9.5) *µm. Habitat in savanna humida. In subsectione Vittadiniis stirpis Vittadinii amplitudinae basidiocarpi, praesentia et forma bulbi basilaris stipitis, praesentia particula dextrinoidea in basidiis, et amplitudine et forma sporarum distinguenda. Holotypus*: Colombia, Dpto. del Meta, Mpio. Puerto Gaitan, Puente Arimena, sobre la carretera a Carimagua, 18.v.1992 A. E. Franco-Molano 850 (NY).

ETYMOLOGY: "of the savanna."

PILEUS: 12–30 mm wide, white to grayish brown (6B2), convex to planar to concave; *context* white, unchanging when cut or bruised, 2^{+} mm thick at stipe; *margin* nonstriate, appendiculate, decurved to inflexed at first, eventually flaring upward, entire; *universal veil* as fine squamules, densest over disk, brown (6E5).

LAMELLAE: free, subclose, white, unchanging when cut or bruised, ventricose, not marginate, $2^{\pm}$ mm broad; *lamellulae* attenuate, of at least two lengths.

STIPE: 13–30 (including bulb) × 4–7 mm, pallid, narrowing upward or downward or subcylindric, smooth and glabrous toward the apex, covered with rather fine and pallid fibrillose scales below annulus; *bulb* subnapiform; *context* white, unchanging when cut or bruised, solid; *partial veil* white, membranous, median to inferior, sometimes left in part on pileus margin or covering the outer portion of lamellae; *universal veil* distributed on the lower stipe as scales (see above) and in broken ring of pallid tissue around apex of bulb.

Odor mild. *Taste* not recorded.

MACROCHEMICAL TESTS: Spot test for tyrosinase (paracresol) - positive throughout basidiocarp after 30 min. Spot test for laccase (syringaldazine) - negative throughout basidiocarp. Test voucher: Franco-Molano 850.

PILEIPELLIS: lacking; pileus context intergrading with universal veil through region with elements more closely packed than lower in pileus context. PILEUS CONTEXT: filamentous, undifferentiated hyphae 1.2–9.8 μm wide, intergrading with narrow inflated cells, occasionally having intercalary inflated cells similar to the acrophysalides of this tissue, branching, walls thin or slightly thickened as in the acrophysalides; acrophysalides subfusiform to narrowly fusiform to clavate to fusiform-rostrate to narrowly clavate to elongate-ellipsoid, up to 169 × 26 μm, dominating, sometimes branching, with walls thin or thickened (up to 0.8 μm thick), often with subradial orientation; vascular hyphae 3.2–8.0 μm wide, branching, common; clamps observed. LAMELLA TRAMA: bilateral, with central stratum (w_{cs} = 25–35 μm) appearing dark and quite distinct at low magnification, with angle of divergence from very shallow to nearly perpendicular to the central stratum; filamentous, undifferentiated hyphae 1.8–6.0 μm wide, branching; terminal, inflated cells not observed; vascular hyphae not observed. SUBHYMENIUM: a branching structure of short uninflated hyphal segments, with w_{st}-near = 15 μm and w_{st}-far = 45 μm, rather small partially inflated to inflated (e.g., 10 × 8.5 μm) intercalary cells, and irregular (e.g., branched) elements, densely interwoven, with elements approaching bases of basidia at 45–90° angle, with most basidia arising from uninflated hyphal segments, but some (especially in regions that are generally more inflated) arising from small inflated cells. BASIDIA: 32–64 × 10.0–14.0 μm, 4-sterigmate, containing dextrinoid granules; clamps rather plentiful. UNIVERSAL VEIL: *On pileus*: extensively gelatinized, more yellow-brown than adjacent pileus context, with elements having periclinal orientation, with most extensively gelatinized regions red-brown and amorphous; filamentous, undifferentiated hyphae 2.5–6.2 µm wide, branching; inflated cells in chains, dominant, subfusiform to narrowly clavate, up to 53 × 21 µm, all badly damaged in material reviewed; vascular hyphae not distinguished due to extensive gelatinization. *On stipe base*: (from broken ring at bulb apex) slightly sordid in mass; filamentous, undifferentiated hyphae 3.0–8.5 µm wide, branching, plentiful; inflated cells in easily dissociated chains, dominant, elongate to cylindric to clavate to ellipsoid, up to 99 × 29 µm, with walls thin to slightly thickened to 0.8 µm thick; vascular hyphae not observed; clamps present. STIPE CONTEXT: longitudinally acrophysalidic; filamentous, undifferentiated hyphae 2.2–8.8 µm wide, dominating, branching; acrophysalides subfusiform to clavate, rather slender, up to 158 × 45 µm, with walls thin or slightly thickened; vascular hyphae 5.0–18.5 µm wide, branching; clamps present. PARTIAL VEIL: upper surface partially gelatinized; filamentous, undifferentiated hyphae 1.0–6.5 µm wide, branching, dominating, criss-cross interwoven; inflated cells terminal, unevenly distributed, subclavate to subfusiform, up to 114 × 36 µm, with slightly thickened walls; vascular hyphae not observed; clamps present.

BASIDIOSPORES: [140/7/1] (6.5–) 7.2–10.8 (–13.5) × (6.0–) 6.2–8.5 (–9.5) µm, (**L** = 7.6–9.2 (–10.2) µm; **L'** = 8.6 µm; **W** = 6.6–7.6 (–8.2) µm; **W'** = 7.2 µm; Q = (1.02–) 1.08–1.36 (–1.73); **Q** = 1.14–1.22 (–1.27); **Q'** = 1.19), hyaline, smooth, thin-walled, amyloid to somewhat palely amyloid, subglobose to broadly ellipsoid to ellipsoid, occasionally globose, occasionally elongate, often not adaxially flattened; apiculus sublateral, proportionately small to very small, cylindric; contents multiguttulate; color in deposit unknown.

ECOLOGY : Subgregarious to gregarious. At 120 m elev. In wet savanna, apparently without nearby woody plants, recently flooded by heavy rains.

MATERIAL EXAMINED: **COLOMBIA**: EL META—Mpio. Puerto Gaitan - Puente Arimena, sobre la carretera a Carimagua, 18.v.1992 A. E. Franco-M. 850 (holotype, NY; isotype, COL; isotype, RET).

NOTES: This taxon is easily keyed to *Amanita* stirps *Vittadinii* using the keys of Bas (1969). The species most similar to *A. savannae* that is treated by Bas (1969) is *A. codinae* (Maire) Bertault (1955), described from the Mediterranean region. However, *A. codinae* has a rather thickset habit (pileus up to 130 mm wide) with a roughly cylindric stipe (up to 80 mm long) that lacks both a bulb and a point at the bottom; and it has much larger spores than does *A. savannae* with **Q** between 1.45 and 1.60.

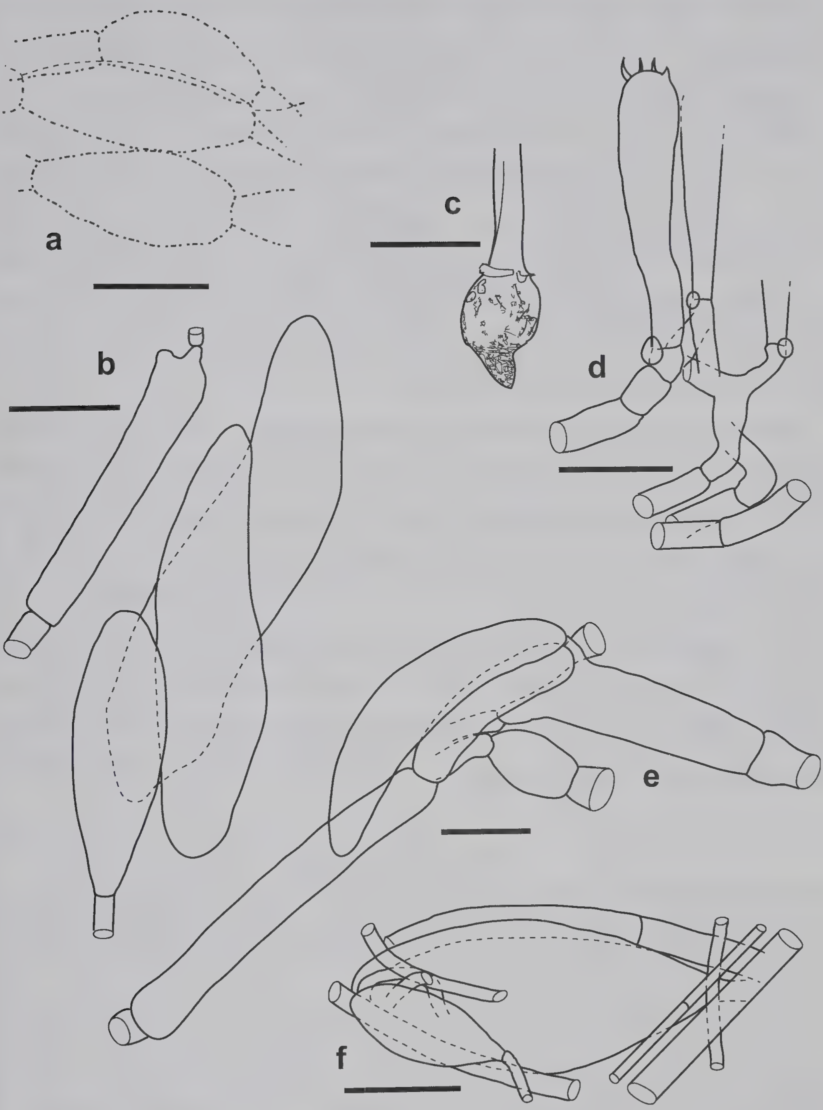

Fig. 1. *Amanita savannae* (holotype). a. Elements of gelatinized universal veil on pileus. b. Elements of universal veil from stipe base. c. Exsiccatum, stipe base. d. Elements of hymenium and subhymenium. e. Elements of pileus context subjacent to universal veil. f. Elements of partial veil. For stipe base, scale bar = 1 cm; for all microscopic drawings, = 20 µm.

Described from the State of Paraná, southern Brazil, *Amanita grallipes* Bas & de Meijer (1993) differs in being. larger (pileus up to 90 mm wide; stipe up to 120 mm long) with downward tapering stipe lacking a bulb, lamellae becoming golden yellow (4A6) in age, and smaller spores with higher **Q** value.

Among the remaining taxa of subsect. *Vittadiniae* described since the publication of (Bas 1969), the only other taxon with which *A. savannae* might be confused is *A. pleropus* (Kalchbr. & MacOwan) D. A. Reid (1975) described from South Africa (Reid & Eicker 1991, 1996). However, there are marked differences between the two species. *Amanita pleropus* has a universal veil with elements having anticlinal orientation. As a result the universal veil remnants on the pileus sometimes become "densely crowded, erect, hair-like spines or pyramidal warts." The African species also has larger spores (10.8–14.0 × 7.0–9.5 µm) with **Q** in the range of $1.5^{\pm}$.

Dextrinoid (or possibly dextrinoid) contents of basidia or spores is a character reported for two other species in *Amanita* sect. *Lepidella*—*A. mutabilis* Beardslee (Bas 1969, Tulloss 1984), belonging to subsect. *Limbatulae* Bas and *A. westii* (Murrill) Murrill (Bas 1969, Tulloss and Lewis 1994), belonging to subsect. *Solitariae* Bas. This paper provides the first report of dextrinoid granules in *Amanita* subsect. *Vittadiniae*. These granules apparently occur rarely outside of *Amanita* subgen. *Lepidella* (E.-J. Gilbert) Beauseign. emend. Corner & Bas; they have been noted by Tulloss (unpub. data) in *A. umbrinolutea* var. *flaccida* D. A. Reid (1987) of *Amanita* sect. *Vaginatae* (Fr.) Quél. sensu Yang (1997) and others. Such granules were considered of taxonomic importance in the case of *A. mutabilis*; however, whether or not they are genetically determined is an open issue.

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Zygophiala (hyphomycetes) — a genus newly recorded from China

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Abstract — We document the first report of the genus *Zygophiala* from China. The fungus *Zygophiala wisconsinensis* was isolated from colonies on the cuticle of apple fruit collected from 2 orchards in Shaanxi and Henan Provinces. Conidiophores were erect, scattered, subcylindrical, irregularly flexuous, s-shaped, consisting of four parts: a hyaline supporting cell that gives rise to a smooth, dark brown stipe, terminating in a finely verruculose, medium brown apical cell that gives rise to two or one medium brown, finely verruculose, doliiform to ellipsoidal, polyblastic conidiogenous cells, with 1-2 prominent scars, apical and lateral, darkened, thickened. Conidia were solitary, fusiform to obclavate, hyaline, smooth and thick-walled, transversely 1-septate, prominently constricted at the septum; apex obtuse, base subtruncate, with a darkened, thickened hilum.

Key words —flyspeck, internal transcribed spacer, rDNA, phylogenetic analysis

Introduction

Flyspeck is a complex of fungi that blemishes the cuticle of pome fruits throughout moist temperate regions of the world. Colby (1920) reported that flyspeck was caused by *Leptothyrium pomi* (Mont. & Fr.) Sacc. Von Arx (1959) synonymized 14 species, including *Leptothyrium pomi*, to *Schizothyrium pomi* (Mont. & Fr.) Arx., the currently accepted name. Martyn (1945) reported *Zygophiala jamaicensis* E.W. Mason as the pathogen of leaf speckle of banana in Jamaica. The link between *S. pomi* and its *Zygophiala* anamorph was reported by Durbin et al. (1953), who inoculated immature apple fruit with ascospores, which produced both the teleomorph and anamorph states. *Schizothyrium pomi* and its *Zygophiala* anamorph were reported to cause greasy blotch of carnation and flyspeck of apple in the United States (Baker et al. 1977). Evidence that *S. pomi* and *Z. jamaicensis* are the same species remains anecdotal, however. Baines (1940), Baker et al. (1977) and Nasu & Kunoh (1987) reported that *Z. jamaicensis* occurred on 120 species in 44 families of plants. Based on surveys of apple orchards in the midwestern and eastern U.S., Batzer et al. (2008) described four new species of the genus *Zygophiala*. They suggested that *S. pomi* might not be the teleomorph of *Z. jamaicensis*, based on difference in size of conidia between the anamorph of *S. pomi* and *Z. jamaicensis*.

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*Corresponding author.

Materials and methods

In September 2006, apples with flyspeck signs were collected from 2 orchards; isolate BJ34 was from Baoji County, Shaanxi Province, and isolate LB15 was from Lingbao County, Henan Province. The thalli were transferred to a potato dextrose agar (PDA) slant directly from the apple fruit surface, and then incubated at 25°C in darkness (Sun et al. 2003). The characteristics of 2- to 4-wk-old cultures on PDA and on OA were described and photographed (Fig. 1).

Table 1 Sequences downloaded from GenBank

GenBank code	Teleomorph	Anamorph	Reference
AY598854		*Zygophiala cryptogama*	Batzer et al. 2008
EF164900		*Z. cryptogama*	Batzer et al. 2008
EF164899		*Z. cryptogama*	Batzer et al. 2008
AY598848	*Schizothyrium pomi*		Batzer et al. 2008
EF164898	*S. pomi*		Batzer et al. 2008
AY598850	*S. pomi*		Batzer et al. 2008
AY598853		*Z. wisconsinensis*	Batzer et al. 2008
AY598855		*Z. wisconsinensis*	Batzer et al. 2008
AY598856		*Z. tardicrescens*	Batzer et al. 2008
AF173313		*Mycosphaerella molleriana*	Crous et al. 1999

POLYMERASE CHAIN REACTION AND SEQUENCING. —Template DNA was extracted according to the method of Barnes et al. (2001), and primer pairs used for amplification and sequencing of the ITS region were ITS1-F (Gardes et al. 1993) and ITS4 (White et al. 1990). Amplification was completed with the following cycling parameters: initial denaturation at 94°C for 3 min followed by 35 cycles of denaturation at 94°C for 30 s, annealing at 52°C for 30 s, and extension at 72°C for 10 min. The PCR products were sequenced by the Organism Technology Co., Ltd., Shanghai, China. Accession Number in GenBank is EU329727 for isolate BJ34, EU825775 for isolate LB15.

SEQUENCE ALIGNMENT AND PHYLOGENETIC ANALYSIS. —The ITS nucleotide sequences generated in this study were added to other sequences downloaded from GenBank (Table 1), with high homology according to a BLAST search (National Center for Biotechnology Information's nucleotide blast program). Preliminary alignments were performed using CLUSTAL-X. The alignments were imported into BioEdit 5.0.9.1 and manually adjusted. Phylogenetic analysis of aligned DNA sequences was performed with PAUP version 4.0b10 for 32-bit Microsoft Windows (Swofford 2001). Heuristic searches were performed with 1000 random sequence additions. The clade stability was evaluated by 1000 bootstrap replications. Other measures for parsimony, including tree length, consistency index, retention index and rescaled consistency index (CI, RI and RC, respectively), were also calculated. *Mycosphaerella molleriana* was used as the outgroup taxon.

Results

On the surface of apple fruit, the fungus produced dark, shiny, round to oval, slightly protuberant sclerotium-like bodies, 344 (286–357) × 473 (357–607) µm.

COLONIES on OA when 2- to 4-week old spreading with aerial mycelium and smooth, regular margins; the middle of colonies olivaceous gray, outer zone pale white; diameter of 2-week growth at 25°C 5 mm. CONIDIOPHORES arising from superficial hyphae, 2-3 µm wide, scattered, 1-septate, subcylindrical, irregularly flexuous, consisting of a hyaline supporting cell that gives rise to a smooth, dark brown stipe, 15–20 × 4–6 µm, (from basal septum to below phialide); terminating in a finely verruculose, medium brown apical cell, 3–5 × 4–6 µm, that gives rise to two or one medium brown, finely verruculose, doliiform to ellipsoidal, polyblastic conidiogenous cells, 5–7 × 4–5 µm, with 1–2 prominent scars, apical and lateral, darkened, thickened, somewhat refractive, 2–3 µm wide. CONIDIA solitary, fusiform to obclavate, hyaline, smooth and thick-walled, granular, aseptate, 14–22 × 6–9 µm, or transversely 1-septate (rarely median), prominently constricted at the septum; apex obtuse, base subtruncate, with a darkened, thickened hilum, 2–3 µm wide.

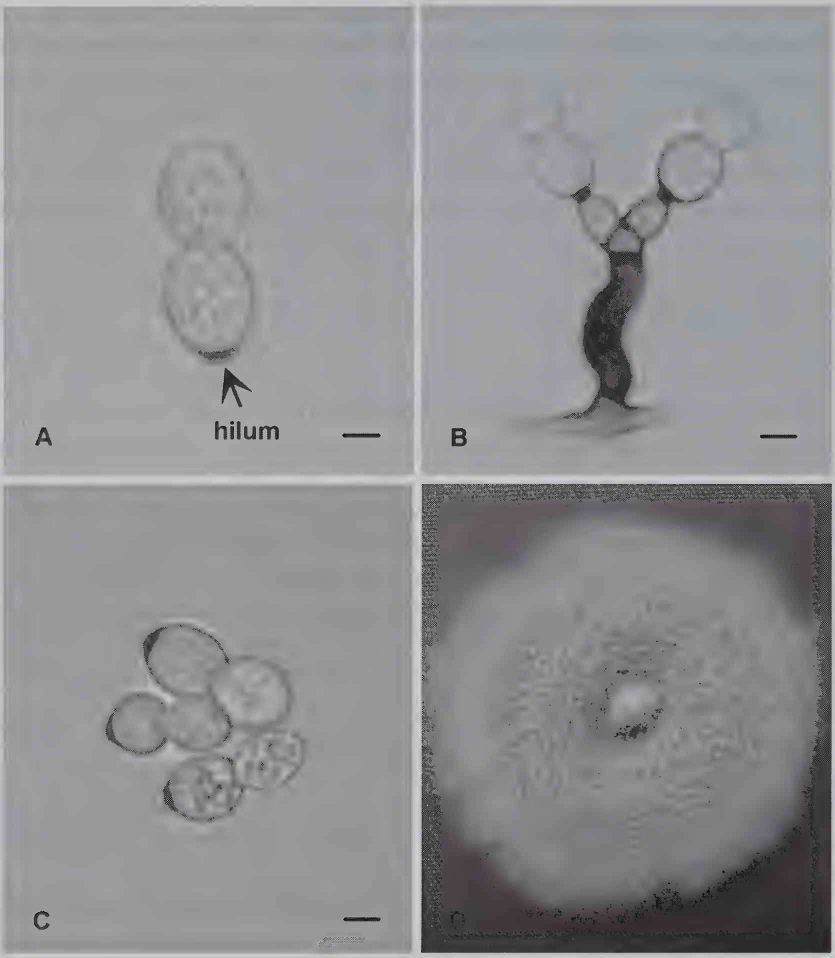

Fig. 1 *Zygophiala wisconsinensis* BJ34
A-C, conidia and conidiophores; D, colony on PDA; bars (A–C) = 3 µm, bars (B) = 5 µm

ITS sequences were generated from two isolates (BJ34, LB15) obtained from the cuticle of apple fruit. Ten GenBank ITS sequences were aligned with the two isolate sequences to generate a majority consensus tree (Fig. 2) with 90 length (CI = 0.9140, RI = 0.8788, RC = 0.8032). One clade with 77% bootstrap support included several strains of *S. pomi* and *Z. cryptogama* Batzer & Crous; the second clade had 79% bootstrap support. Isolates BJ34 and LB15 grouped with *Zygophiala wisconsinensis* Batzer & Crous with 94% bootstrap support.

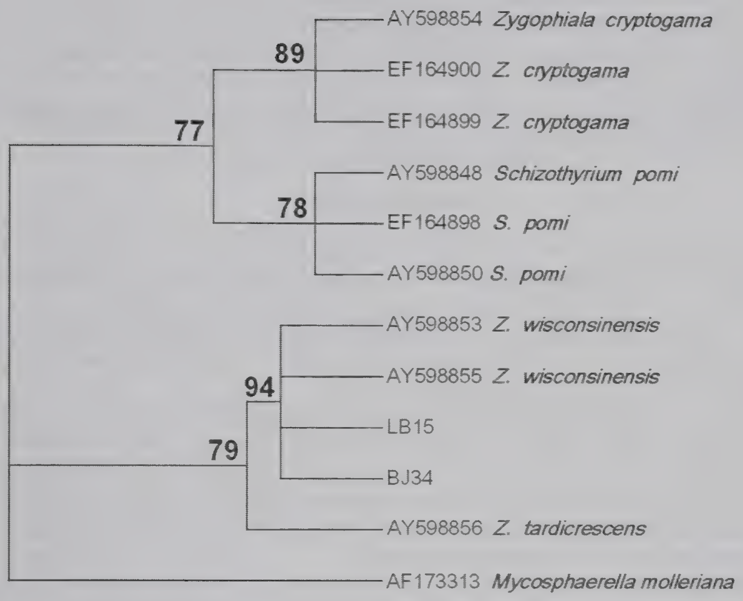
89
77
78
94
79
AY598854 Zygophiala cryptogama
EF164900 Z. cryptogama
EF164899 Z. cryptogama
AY598848 Schizothyrium pomi
EF164898 S. pomi
AY598850 S. pomi
AY598853 Z. wisconsinensis
AY598855 Z. wisconsinensis
LB15
BJ34
AY598856 Z. tardicrescens
AF173313 Mycosphaerella molleriana

Fig. 2 The majority consensus tree (length = 93, CI = 0.9140, RI = 0.8788, RC = 0.8032) derived from a heuristic search option in PAUP version 4.0b10 for 32-bit Microsoft Windows with 1000 randomizations of sequence input orders and 1000 bootstrap replications using the data set of ITS1, 5.8S and ITS2. Bootstrap values > 50% are indicated above the tree branches.

Discussion

This is the first report of the genus *Zygophiala* and of *Z. wisconsinensis* on apple in China. *Zygophiala* spp. can be distinguished by colony and conidial morphology. *Z. tardicrescens* Batzer & Crous can be differentiated from *Z. wisconsinensis* by diameter growth on MEA. The sclerotium-like bodies of *Z. wisconsinensis* on pome fruit also tend to be ovoid, larger, and more sparsely arranged than for other flyspeck species (Batzer et al. 2008). Our research indicates that strains isolated from the apple cuticle grew more quickly on PDA than on OA, with conidial morphology and size matching those of *Z. wisconsinensis*. DNA sequence analyses of both isolates also demonstrate their close relationship with *Z. wisconsinensis*. Based on these characters we identified the isolates as *Z. wisconsinensis*.

Acknowledgments

This work was supported by National Natural Science Foundation of China (30670013 and Key Project No. 30630054) and Program for Changjiang Scholars and Innovative Research Team in University (No. 200558 and IRT0748). The authors wish to thank Professors Turner B. Sutton (North Carolina State University, Raleigh, NC, U.S.A.) and Zhongyi Zhang (College of Plant Protection, Yunnan Agricultural University, Kunming, Yunnan, China) for reviewing the manuscript.

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MYCOTAXON

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Two new species and a new Chinese record of *Exobasidium* (*Exobasidiales*) from China

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Abstract—Two new species, *Exobasidium rhododendri-nivalis* on *Rhododendron nivale* and *E. pyroloides* on *Gaultheria pyroloides*, are reported. They were collected from Yunnan and Sichuan Provinces. *Exobasidium rhododendri-nivalis* causes small galls on leaves, stems and shoots, while *E. pyroloides* causes red leaf spots. *Exobasidium cylindrosporum* on *Rhododendron* sp., collected from Jiangxi Province, is reported as new to China.

Key words—*Ustilaginomycetes*, symptoms, taxonomy

Two new species of *Exobasidium*, collected from southwestern China, are described and illustrated. The first new species was collected in 2007 from Yunnan and Sichuan Provinces at altitudes of 4300 m and 4650 m. It is parasitic on *Rhododendron nivale* (subfamily *Rhododendroideae* of *Ericaceae*), causing small galls measuring 1–4 mm in diam. on leaves, stems and shoots. On leaves there are 1–5 (or more) galls on the lower surface. Diseased leaves are convex on the upper surface. The galls are red when fresh and become pale yellowish brown to black when old. Basidiospores with short germ tubes were observed in some microscopical slides of fresh material. The new species is described as:

Exobasidium rhododendri-nivalis ZhenYing Li & L. Guo, **sp. nov.** **Figs. 1, 4-7**
MYCOBANK MB 511910

Hymenium album. Basidia clavata vel cylindrica, 7–18 × 4–8 µm, hyalina, terminaliter 2–4 sterigmatibus 4.5–7 × 1–1.5 µm praedita. Basidiosporae ellipsoideae, curvae, 10.2–13 × 2.5–3 µm, hyalinae, laeves, primo continuae, dein 1-septatae; per hyphas germinantes.

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*corresponding author

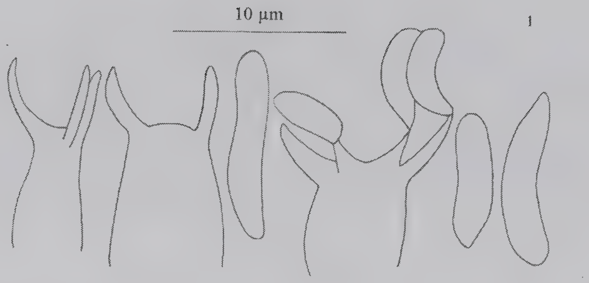

Fig. 1. Line drawings of basidia, sterigmata and basidiospores of *Exobasidium rhododendri-nivalis* on *Rhododendron nivale* (HMAS 183431, holotype).

Hymenium white, forming a continuous layer over the surface of a gall. Basidia clavate or cylindrical, 7–18 × 4–8 µm, hyaline, with 2–4 sterigmata. Sterigmata conical, 4.5–7 × 1–1.5 µm. Basidiospores ellipsoidal, 10.2–13 × 2.5–3 µm, hyaline, smooth, at first continuous, then 1-septate, and slightly curved; germinating by germ tubes.

Specimens examined—On *Rhododendron nivale* Hook.f. (*Ericaceae*), Yunnan: Deqen, Baimaxue Mountain, alt. 4300 m, 21 IX 2007, Z.Y. Li, L. Guo & S.H. He 697, HMAS 183431 (**holotype**); Sichuan: Xiangcheng, alt. 4650 m, 24 IX 2007, Z.Y. Li, L. Guo & S.H. He 716, HMAS 183444 (**paratype**)

Exobasidium rhododendri-nivalis is similar to *E. sakishimaense* Otani (1976) although the latter has larger basidiospores (15–24 × 5–6 µm vs. 10.2–13 × 2.5–3 µm).

The second new species parasitizes young leaves of *Gaultheria pyroloides* (subfamily *Gaultherioideae* of *Ericaceae*), causing leaf spots that are red on the upper surface. The host plant belongs to the subfamily *Gaultherioideae* of *Ericaceae*. There are one or two diseased parts on each leaf. Transverse sections of the diseased leaf show hypertrophy of plant cells. Hyphae protrude between epidermal cells, forming a continuous thick layer on the lower surfaces of the leaves at maturity. There are 2–4 sterigmata per basidium.

Exobasidium pyroloides **ZhenYing Li & L. Guo, sp. nov.** **Figs. 2, 8-10**

MycoBank MB 511911

Hymenium album, hypophyllum. Basidia cylindrica, 3.5–6 µm lata, hyalina, terminaliter 2–4 sterigmatibus (2–)3–5(–6) × 1–1.5(–2) µm praedita. Basidiosporae cylindricae vel obovoideae, (7–)9–13 × 3–4(–5) µm, hyalinae, laeves, primo continuae, dein 1(–2)-septatae.

Hymenium white, hypophyllous. Basidia cylindrical, 3.5–6 µm wide, hyaline, with 2–4 sterigmata. Sterigmata conical, (2–)3–5(–6) × 1–1.5(–2) µm. Basidiospores cylindrical or obovoid, (7–)9–13 × 3–4(–5) µm, hyaline, smooth, at first continuous, then 1(–2)-septate.

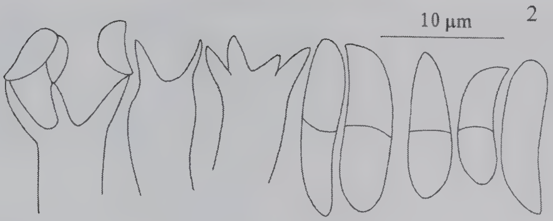

Fig. 2. Line drawings of basidia, sterigmata and basidiospores of *Exobasidium pyroloides* on *Gaultheria pyroloides* (HMAS 183432, holotype).

SPECIMEN EXAMINED—On *Gaultheria pyroloides* Hook.f. & Thomson ex Miq. (*Ericaceae*), Yunnan: Tengchong, Xiaodifang, alt. 2180 m, 19 IX 2005, Z.Y. Li, L. Guo & N. Liu 201, HMAS 183432 (**holotype**).

Exobasidium pyroloides is similar to *E. gaultheriae* Sawada on *Gaultheria cuneata* Bean from which it mainly differs in having 2–4 sterigmata and forming leaf spots; *E. gaultheriae* has 3–6 sterigmata and forms galls.

A third species of *Exobasidium* is a new Chinese record. This species is parasitic on young leaves of *Rhododendron* sp., causing convex or concave galls on the upper surface. The diseased parts are ellipsoidal, usually 9–13 × 4–6.5 mm in size. There are one or more diseased parts on each leaf. Transverse sections of the diseased leaf show that there is hypertrophy of plant cells. Hyphae protrude between epidermal cells, forming a continuous layer on the lower surfaces of the leaves at maturity. It is identified as *Exobasidium cylindrosporum* (Ezuka 1990), which was described from Japan on *Rhododendron macrosepalum* Maxim..

Exobasidium cylindrosporum Ezuka, Trans. Mycol. Soc. Japan 31: 451, 1990.

Figs. 3, 11-13

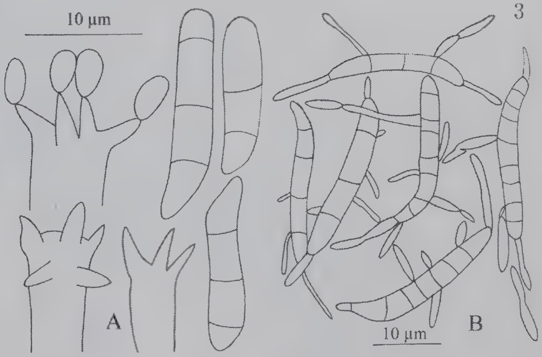

Fig. 3. *Exobasidium cylindrosporum* on *Rhododendron* sp. (HMAS 183415). A. Basidia, sterigmata and basidiospores. B. Basidiospore germination.

Basidia cylindrical, 17–30 × 4–6(–8) µm, hyaline, with 3–5(–6) sterigmata. Sterigmata conical, (3.2–)4–5.5(–7) × 1.2–2 µm. Basidiospores cylindrical, 15–20.5 × (3.5–)4(–4.8) µm, hyaline, smooth, at first continuous, with 3–8 septa when germinating, and slightly curved at the base. Short germ tubes emerge from cells at both ends of the basidiospores and from near septa of intermediate cells 24 h after dropping.

Specimen examined—On *Rhododendron* sp. (*Ericaceae*), Jiangxi: Lushan, alt. 1080 m, 14 V 2007, Z.Y. Li & L. Guo 638, HMAS 183415.

Colonies on PDA grew slowly, to a maximum 10 mm diameter after 21 days incubation at 25°C. The colony was yellow and corrugate on the surface, composed of hyphae and conidia. Conidia linear, 9–20 × 1 µm.

To date, 29 species of *Exobasidium* have been recorded in China (Sawada 1922, Teng 1963, Tai 1979, Guo et al. 1991, Zang 1996, Li & Guo 2006a, b, 2008a, b) including the three species in this paper.

Acknowledgements

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Figs. 4-7. *Exobasidium rhododendri-nivalis* on *Rhododendron nivale* (HMAS 183431, holotype). Fig. 4. Symptoms. Fig. 5. Basidiospores and germ tubes as seen by LM. Fig. 6. Basidia and sterigmata as seen by LM. Fig. 7. Basidia, sterigmata and basidiospores as seen by SEM. **Figs. 8-10.** *Exobasidium pyroloides* on *Gaultheria pyroloides* (HMAS 183432, holotype). Fig. 8. Basidia and sterigmata as seen by LM. Figs. 9. Basidiospores as seen by LM. Fig. 10. Basidia, sterigmata and basidiospores as seen by SEM. **Figs. 11-13.** *Exobasidium cylindrosporum* on *Rhododendron* sp. (HMAS 183415). Fig. 11. Symptoms. Fig. 12. Basidium, sterigmata and basidiospores as seen by LM. Fig. 13. Basidium, sterigmata and basidiospores as seen by SEM.

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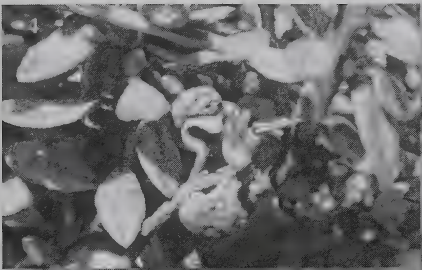

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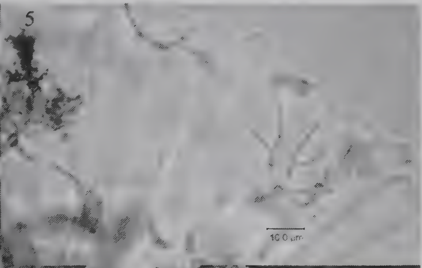

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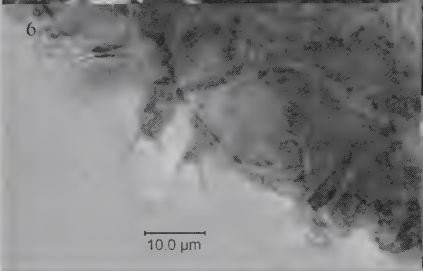

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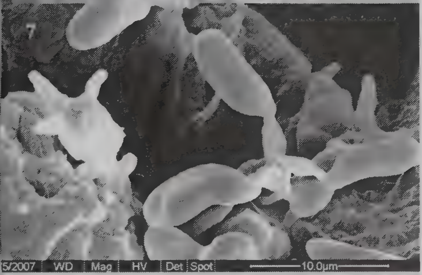
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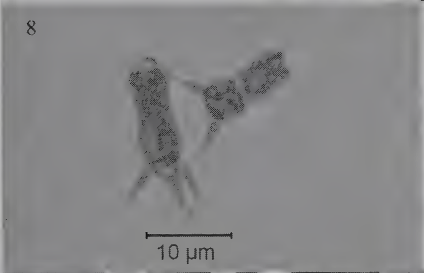

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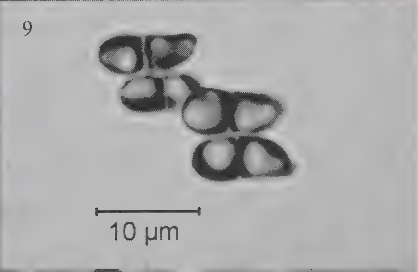

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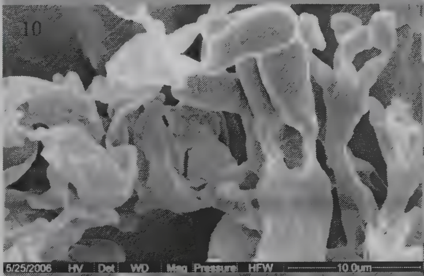
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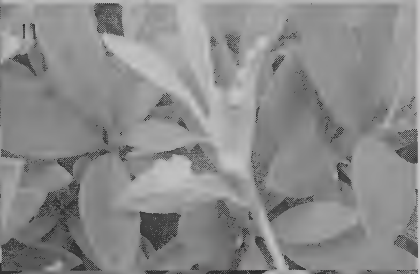

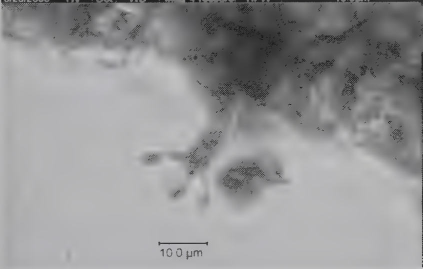

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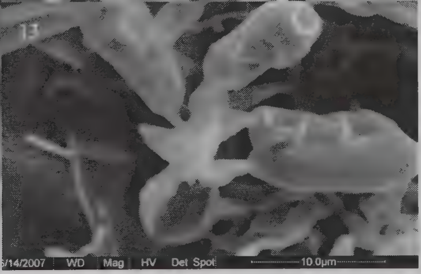
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A new anamorphic fungus from Venezuela: *Pyriculariopsis formosa*

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Abstract — *Pyriculariopsis formosa* anam. sp. nov. found on a decaying leaf of *Clusia rosea* in 'Cerro El Ávila', Caracas, Venezuela, is described and ilustrated. This species is characterized by erect, robust, unbranched conidiophores and obclavate, slightly rostrate, 5- to 7-septate, smooth conidia with two dark brown cells and the other conidial cells subhyaline. A key and illustrations of conidia of all *Pyriculariopsis* species are provided.

Key words — conidial fungi, leaf litter, systematics, tropical rainforest

Introduction

During an expedition in 2007 to "Cerro El Ávila" near Caracas, Venezuela, a conspicuous anamorphic fungus from the genus *Pyriculariopsis* was collected.

Morphologically the fungus was distinctly different from previously described species and is therefore described as a new species.

Materials and methods

Samples of plant material were placed in separate paper bags and taken to the laboratory for examination of microfungi. Mounts were prepared in polyvinyl alcohol-glycerol (8 g in 100 ml of water, plus 5 ml of glycerol) and measurements made at a magnification of × 1000. Micrographs were obtained with a Leitz Biomed microscope.

Taxonomy

Pyriculariopsis formosa Rob. Fernández, R. F. Castañeda & Iturr. **anam. sp. nov.**

MYCOBANK #: MB511740 **Figs. 1-8**

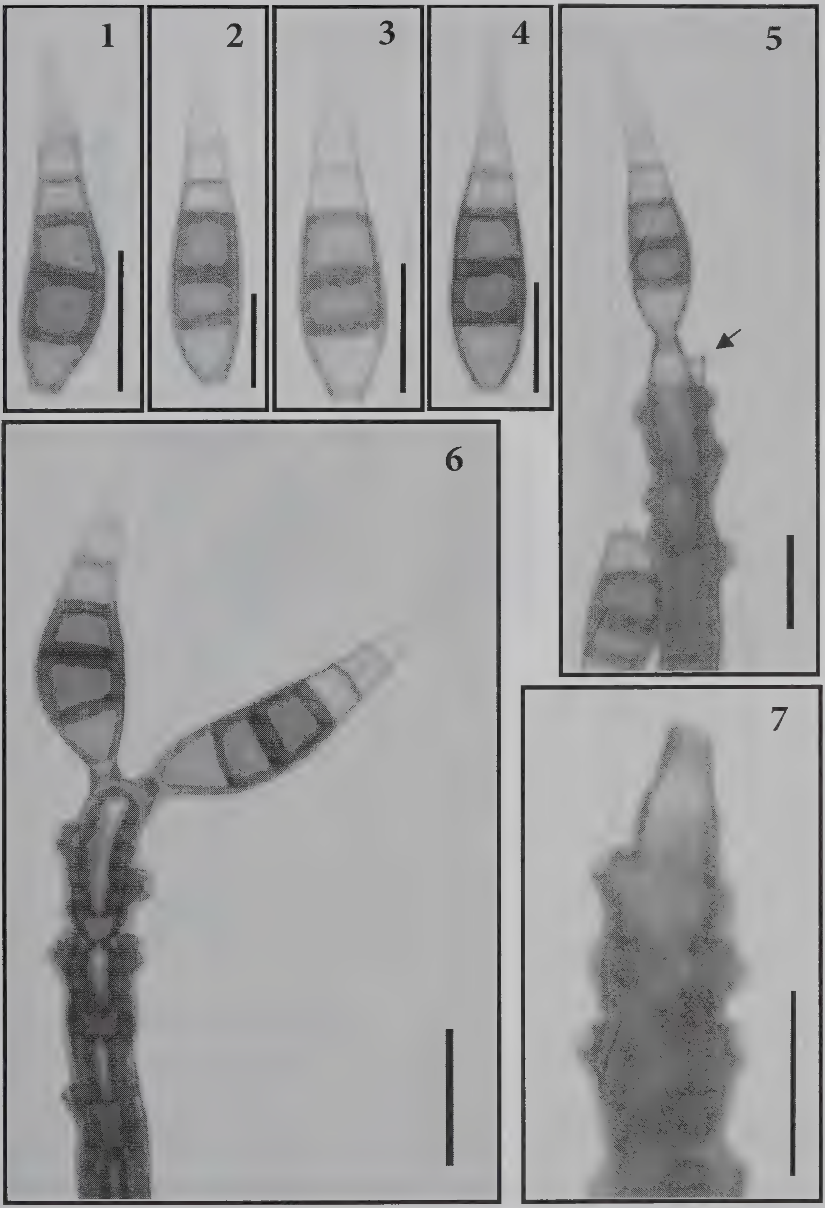
Ad omnibus speciebus Pyriculariopsis *differt in conidiophoris robustis, eramosis, 86–230 µm altis, 5–8 µm crassis ad basim, atrobrunneis. Conidia obclavata, leviter rostrata, 5- ad 7-septata, laevia, sicca. 19–32 × 5–8 µm, cum cellulis secunda et tertia atrobrunneis et cetero dilute brunneis usque ad subhyalinis.*

VENEZUELA, Caracas, "Cerro El Ávila", Parque Nacional El Ávila, near "Lagunazo" camping field, on decaying leaf of *Clusia minor* L. 10°33'1.9" N and 66°51'48.8"W, 2243 m alt, 20.XI.2007, coll. R. Fernández. **HOLOTYPE:** VEN 395730.

ETYMOLOGY: Latin, *formosus*, meaning pretty and elegant.

COLONIES on the natural substratum effuse, pilose, epiphyllous, dark brown to black. Mycelium mostly immersed composed of septate, branched, smooth-walled, 2–4 µm diam. brown hyphae. CONIDIOPHORES macronematous, mononematous, robust, erect, straight or flexuous, 8 to 12-septate, dark brown, smooth, 86–230 µm tall, 5–8 µm wide at the base. CONIDIOGENOUS CELLS holoblastic, multilocal, integrated, terminal and intercalary, 6–24 × 4–6 µm, indeterminate, sympodially proliferating, with conspicuous, conical-truncated ends, slightly melanized denticles (1–2 × 3 µm); enteroblastic percurrent proliferations rarely seen. CONIDIA solitary, obclavate, slightly rostrate at the apex, 5 to 7-septate, acropleurogenous, smooth, 19–32 × 5–8 µm, pale brown to subhyaline, but with second and third cells dark brown, dry. TELEOMORPH: unknown.

COMMENTS: The genus *Pyriculariopsis* was introduced by Ellis (1971) for a single species, *P. parasitica* M.B. Ellis. Matsushima (1975, 1989), Davydkina & Melnik (1989), Castañeda & Kendrick (1990), Lai & Gao (1991) and Reddy et al (2002) subsequently added seven species: *Pyriculariopsis appendiculata* Matsush., *P. miogae* Matsush., *P. breviphora* Matsush., *P. pleuroconidiophora* Davydkina & Melnik, *P. theobromae* Castañeda & W.B. Kendr., *P. amomi* (Z.D. Jiang & P.K. Chi) X.H. Lai & H.L. Gao and *P. indica* B.S. Reddy et al, but no taxonomic account for the genus has been published. The main diagnostic features of



Figs. 1-7. *Pyriculariopsis formosa* from VEN 395730.
1-4. Conidia. 5-6. Detail of conidiogenous cells and conidia.
7. Conidiogenous cells and denticulate loci.
Bars = 10 µm

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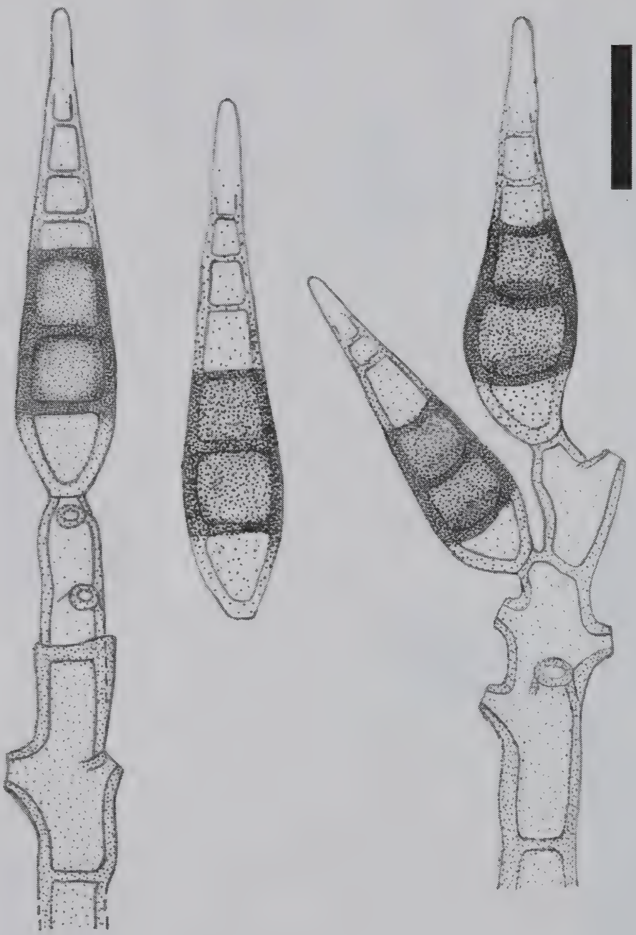
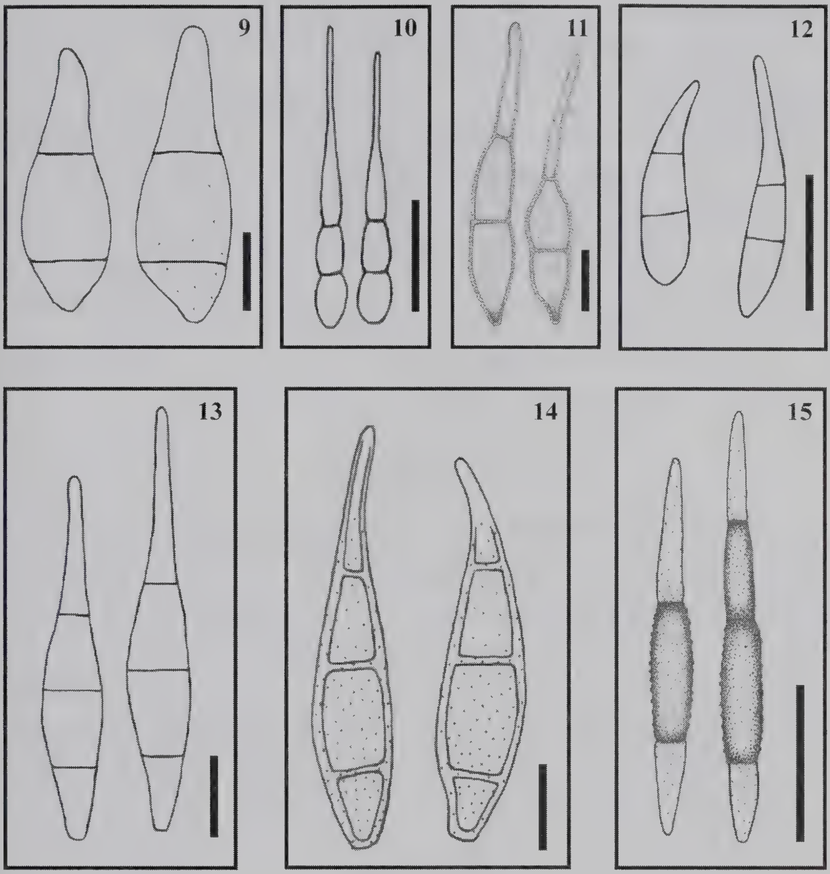


Fig. 8. *Pyriculariopsis formosa* from VEN 395730.
Conidiophore, conidogenous cells and conidia. Bar = 10 µm

Pyriculariopsis are the large, conico-truncate or cylindrical denticles produced after holoblastic sympodial proliferations of the conidiogenous cells, obclavate, subhyaline or hyaline, intermediate cells, and pale brown to brown conidia which are released schizolytically. *P. pleuroconidiophora* was transferred to the genus *Cacumisporium* by Castañeda et al (2007). Published *Pyriculariopsis* species cannot be confused with *P. formosa* because of the difference in number of conidial septa.



Figs. 9-15. Re-drawing of conidia of *Pyriculariopsis* species from literature.
9. *P. amomi*. 10. *P. appendiculata*. 11. *P. breviphora*. 12. *P. indica*.
13. *P. miogae*. 14. *P. parasitica*. 15. *P theobromae*.
Bars = 10 µm

Key to accepted *Pyrculariopsis* species

1 Conidia smooth-walled 2
Conidia with second and sometimes third cells verrucose, 22–32 × 2.5–4 µm, 2- to 3(4)-septate, fusiform , two central cells dark brown, end cells almost colorless . . . . *P. theobromae* (**Fig.15**)

2(1) Conidia 1-septate, cylindrical to fusiform, rostrate, 50-72 × 7.5-10 µm, pale brown, but with hyaline apical cell . . . . *P. breviphora** (**Fig.11**)
Conidia 1- to 3-septate 3
Conidia 5- to 7-septate, 19–32 × 5–8 µm, pale brown to subhyaline but with second and third cells dark brown . . . . *P. formosa*

3(2) Conidiophores twisted near the base, conidia obpyriform to clavate, 20-48 × 7-11 µm, pale brown . . . . *P. amomi* (**Fig.9**)
Conidiophores not twisted 4

4(3) Conidia 1- to 2- septate, obclavate, 15–20 × 3–5 µm, basal and suprabasal cells subhyaline to pale brown, apical cell hyaline . . . . *P. indica* (**Fig.12**)
Conidia 2- septate, rostrate, narrow obclavate, 16–28 × 3–4 µm, basal and suprabasal cells brown, apical cell hyaline . . . . *P. appendiculata* (**Fig. 10**)
Conidia more than 2-septate 5

5(4) Conidia 3-septate, obclavate, rostrate, 30–55 × 9–12 µm, end cells hyaline, intermediate cells pale brown . . . . *P. parasitica* (**Fig.14**)
Conidia 3-septate, broad or narrow fusiform, 45–60 × 6–8 µm, end cells hyaline, intermediate cells pale brown . . . . *P. miogae* (**Fig.13**)

* Described from pure culture on V8 Juice agar.

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Wood-rotting fungi in eastern China 2. A new species of *Fomitiporia (Basidiomycota)* from Wanmulin Nature Reserve, Fujian Province

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Abstract — *Fomitiporia ellipsoidea* sp. nov., collected from Wanmulin Nature Reserve, Fujian Province, eastern China, is described and illustrated. It has a perennial growth habit, resupinate basidiocarp, yellowish brown to rust brown pore surface, dimitic hyphal structure with simple septa, abundant hymenial setae, dextrinoid, cyanophilous and thick-walled basidiospores. It is distinguished from the other species in the genus by having hooked hymenial setae and ellipsoid to broadly ellipsoid basidiospores.

Key words — *Hymenochaetaceae*, lignicolous and poroid fungi, taxonomy

Introduction

Fomitiporia Murrill was established by Murrill (1907), and today the genus is often conceived as the *Phellinus robustus* complex. Species of *Fomitiporia* have hyaline, thick-walled, dextrinoid and cyanophilous basidiospores, and these characters distinguish the genus from *Phellinus* sensu lato. Recent phylogenetic studies have demonstrated that *Fomitiporia* is a distinct group in the family *Hymenochaetaceae* (Decock et al. 2005, Fischer 1996, 2002, Wagner & Fischer 2001, 2002).

Nearly 20 taxa have been transferred to or described in the genus (Dai & Cui 2005, Dai et al. 2001, 2008, Dai & Zang 2002, Decock et al. 2005, Fiasson & Niemelä 1984, Fischer 2002, Fischer & Binder 2004, Fischer et al. 2005), and

10 species of *Fomitiporia* have previously been reported from China (Cui et al. 2007, Dai 1999, Dai & Cui 2005, Dai et al. 2001, 2008, Dai & Niemelä 2006, Dai & Zang 2002).

During the study of wood-rotting fungi from Wanmulin Nature Reserve in Fujian Province, eastern China, five specimens of an unknown taxon were collected, characterized by perennial, resupinate basidiocarps, dimitic hyphal structure with simple septa, abundant hymenial setae, and basidiospores ellipsoid to broadly ellipsoid, hyaline, thick-walled, dextrinoid and cyanophilous. These characters indicate the genus *Fomitiporia*, but with no existing species name for this taxon, in this paper we describe it as new.

Materials and methods

The studied specimens are deposited at the herbarium of Institute of Applied Ecology, Chinese Academy of Sciences (IFP), the herbarium of Beijing Forestry University (BJFC), and the herbarium of the botanical museum of the University of Helsinki (H). The microscopic procedure follows Cui et al. (2007). In presenting the variation in the size of the spores, 5% of measurements were excluded from each end of the range, and are given in parentheses. In the text the following abbreviations are used: IKI = Melzer's reagent, IKI– = negative in Melzer's reagent, KOH = 5% potassium hydroxide, CB = Cotton Blue, CB+ = cyanophilous, CB– = acyanophilous, L = mean spore length (arithmetic mean of all spores), W = mean spore width (arithmetic mean of all spores), Q = variation in the L/W ratios between the specimens studied, n = number of spores measured from given number of specimens. Sections were studied at magnification up to ×1000 using a Nikon Eclipse E600 microscope and phase contrast illumination. Drawings were made with the aid of a drawing tube. Special colour terms are from Petersen (1996) and Anonymous (1969).

Description

Fomitiporia ellipsoidea B.K. Cui & Y.C. Dai, **sp. nov.** **Fig.1**

MycoBank MB 512012

Carpophorum perenne, resupinatum, contextum fulvum. Facies pororum fulva vel ferrugineum; pori rotundi vel sinuolati, 5–8 per mm. Systema hypharum dimiticum, hyphae generatoriae septatae, efibulatae. Sporae ellipsoideae, crassitunicatae, dextrinoidae, CB+, 4.9–6 × 3.9–4.8 µm.

Type. — **China.** Fujian Province, Jian'ou County, Wanmulin Nature Reserve, on fallen angiosperm trunk, 31.VIII.2006 *Cui 4285* (holotype in IFP, isotypes in BJFC and H).

Etymology — *Ellipsoidea* (Lat.): referring to ellipsoid basidiospores.

Fruitbody — Basidiocarps perennial, resupinate, inseparable, woody hard when fresh, without odour or taste, consistency woody hard when dry, up to 30

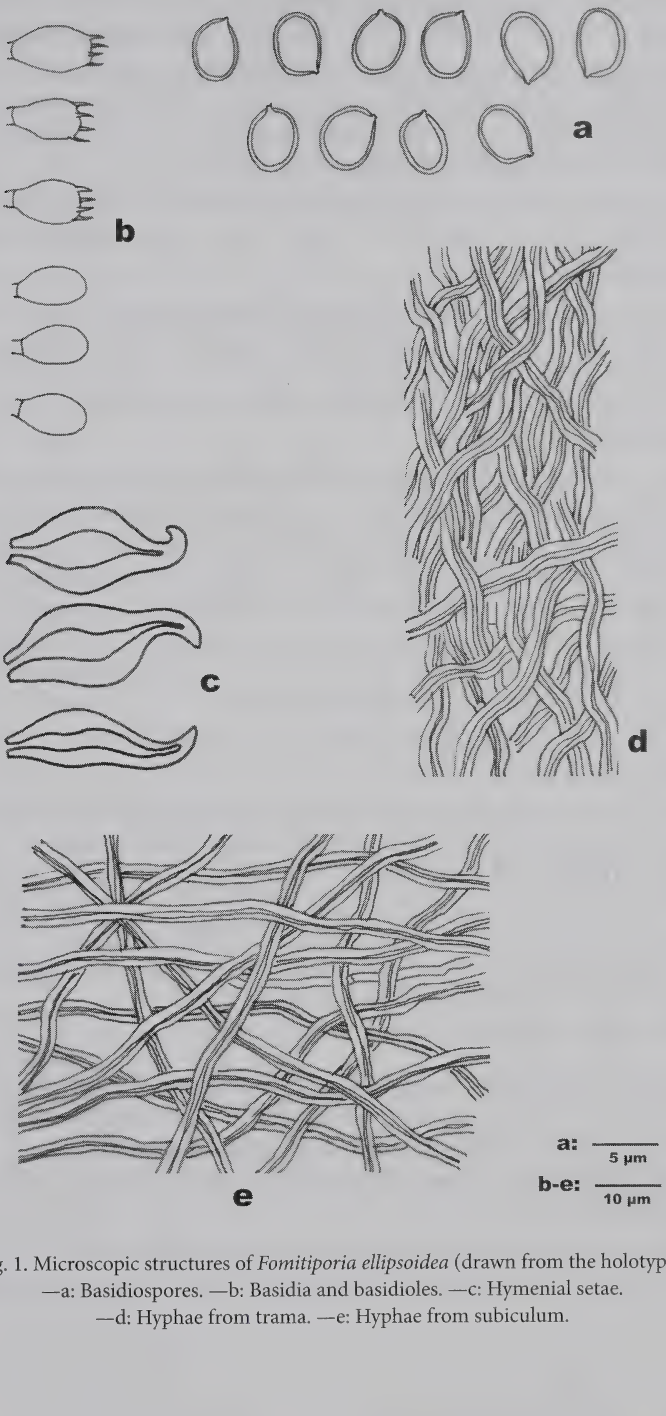

Fig. 1. Microscopic structures of *Fomitiporia ellipsoidea* (drawn from the holotype). —a: Basidiospores. —b: Basidia and basidioles. —c: Hymenial setae. —d: Hyphae from trama. —e: Hyphae from subiculum.

cm or more in longest dimension, 20 cm wide, ca. 8 mm thick at centre; margin yellowish to yellowish brown, up to 2 mm wide. Pore surface yellowish brown to rust brown, shining; pores circular to sinuous at oblique surface, 5–8 per mm; dissepiments slightly thick, entire. Context yellowish brown, woody hard, very thin, less than 0.5 mm thick. Tubes concolourous with the pore surface, woody hard, up to 8 mm long, distinctly stratified.

Hyphal structure — Hyphal system dimitic; all septa without clamp connections; skeletal hyphae IKI–, CB–; tissue darkening but otherwise unchanged in KOH.

Subiculum — Tissue dominated by skeletal hyphae; generative hyphae hyaline, thin- to fairly thick-walled, occasionally branched and frequently simple septate, 2–3 μm in diam.; skeletal hyphae golden brown to rust brown, thick-walled with a narrow to wide lumen, unbranched, interwoven, more or less agglutinated, 2–3.6 μm diam.

Tubes — Tramal hyphae dominated by skeletal hyphae; generative hyphae hyaline, thin- to slightly thick-walled, occasionally branched and frequently simple septate, 1.5–2.6 μm diam.; skeletal hyphae yellowish brown to rust brown, thick-walled to subsolid, unbranched, interwoven, slightly agglutinated, 1.8–3.4 μm diam. Subhymenium indistinct. Hymenial setae present, usually ventricose and hooked, yellowish brown, thick-walled, 20–30 × 10–14 μm; cystidia and cystidioles absent; basidia barrel-shaped to subglobose, with four sterigmata and a simple septum at the base, 8–12 × 6–7 μm; basidioles in shape similar to basidia, but slightly smaller; big rhomboid crystals abundant in hymenia and trama.

Spores — Basidiospores ellipsoid to broadly ellipsoid, hyaline, slightly thick-walled, smooth, weakly dextrinoid in Melzer´s reagent, distinctly CB+, (4.5–)4.9–6(–6.1) × (3.5–)3.9–4.8(–5) μm, L = 5.26 μm, W = 4.14 μm, Q = 1.22–1.32 (n=90/3).

Additional specimens (paratypes) examined. — **China.** Fujian Province, Jian'ou County, Wanmulin Nature Reserve, on fallen angiosperm trunk, 30.VIII.2006 *Cui 4234* (IFP, BJFC); 31.VIII.2006 *Cui 4270, 4277* & *4289* (IFP, BJFC).

Type of rot — White rot.

Remarks — *Fomitiporia ellipsoidea* has a very distinctive morphology with its perennial growth habit, resupinate basidiocarp, hooked hymenial setae, ellipsoid, weakly dextrinoid and cyanophilous basidiospores. It is easily recognized under the microscope because of its hooked setae and ellipsoid basidiospores.

The dextrinoid reaction of basidiospores of *F. ellipsoidea* is not as strong as in most species of *Fomitiporia*, and basidiospore shape is also not typical of the genus. All other features, however, fit the genus well and on that basis we treat it here under *Fomitiporia.*

Five species in *Fomitiporia*, *F. bannaensis* Y.C. Dai, *F. pseudopunctata* (A. David et al.) Fiasson, *F. sonorae* (Gilb.) Y.C. Dai, *F. sublaevigata* (Cleland & Rodway) Y.C. Dai, and *F. tenuis* Decock et al., have resupinate basidiocarps and hymenial setae (Dai 1999, Dai et al. 2001, Decock et al. 2005), but all these five species have straight hymenial setae, and their basidiospores are basically subglobose to globose.

Phellinus caribaeo-quercicola Decock & S. Herrera was recently described from Cuba (Decock et al. 2006), and this species shares with *Fomitiporia ellipsoidea* the hooked hymenial setae and ellipsoid to broadly ellipsoid basidiospores. However, it differs from *F. ellipsoidea* in having resupinate to effused basidiocarps and hyaline to yellowish, nondextrinoid basidiospores. Moreover, it is only known from *Quercus cubana* from tropical America (Decock et al. 2006).

Phellinus uncinatus Rajchenb. has hooked hymenial setae, thick-walled and dextrinoid basidiospores (Decock et al. 2006, Rajchenberg 1987), but its basidiospores are distinctly subglobose to globose, and bigger than those of *F. ellipsoidea* (5.5–7 × 5–6.5 µm, Ryvarden 2004). Furthermore, *P. uncinatus* grows on bamboo exclusively in tropical America (Decock et al. 2005).

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Notes on *Elmerina* and *Protomerulius* (*Basidiomycota*)

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Abstract — Polypores with longitudinally septate basidia are briefly summarized, and a key for 11 species is supplied. *Protomerulius efibulatus* is described as new from China. It is characterized by resupinate basidiocarps, cream to pinkish buff pores, generative hyphae without clamp connections, and ellipsoid basidiospores. It was found on rotten angiosperm wood in tropical forests of southern China.

Key words — lignicolous fungi, poroid fungi, taxonomy

Introduction

Two polypore genera, *Elmerina* Bres. and *Protomerulius* Møller, are macroscopically similar to polypores, having poroid and corky basidiocarps when fresh. However, microscopically species of these two genera have longitudinally septate basidia. Until now, *Protomerulius caryae* (Schwein.) Ryvarden, *P. africanus* (Ryvarden) Ryvarden and *P. brasiliensis* Møller have been recorded in the genus *Protomerulius*; the first-mentioned species occurs commonly in the northern hemisphere and also in Australasia (Gilbertson & Ryvarden 1986, Ryvarden & Gilbertson 1993, Núñez & Ryvarden 2001). *Protomerulius africanus* and *P. brasiliensis* were reported from African and South America (Ryvarden & Johansen 1980, Bandoni et al. 1982). Seven species of *Elmerina* have previously been reported: *E. borneensis* (Jülich) D.A. Reid, *E. cladophora* (Berk.) Bres., *E. dimidiata* (A. David) D.A. Reid, *E. hexagonoides* (A. David & Jaq.) Núñez, *E. holophaea* (Pat.) Parmasto, *E. substuppea* (Berk. & Cooke) T. Hatt. and *E. unguliformis* Corner (Parmasto 1984, Corner 1989, Reid 1992, Núñez 1998, Hattori 2003).

During an investigation of wood-inhabiting fungi in Hainan Province, tropical China, two special specimens were collected with distinctly poroid, resupinate basidiocarps, septate probasidia and longitudinally septate epibasidia. These characters suggest the species belongs in *Protomerulius* (Núñez 1998), but no existing name is available; we therefore describe them herein as a new species. In addition, based mostly on published descriptions, a key to the two polypore genera, *Elmerina* and *Protomerulius,* is supplied.

Materials and methods

The studied specimens are deposited at the herbarium of Institute of Applied Ecology, Chinese Academy of Sciences (IFP), and the Herbarium of Beijing Forestry University (BJFC). The microscopic procedure follows Yuan et al. (2007). In presenting the variation in the size of the spores, 5% of measurements were excluded from each end of the range, and are given in parentheses. In the text the following abbreviations are used: IKI = Melzer's reagent, IKI– = negative in Melzer's reagent, KOH = 5% potassium hydroxide, CB = Cotton Blue, CB+ = cyanophilous, CB– = acyanophilous, L = mean spore length (arithmetic mean of all spores), W = mean spore width (arithmetic mean of all spores), Q = variation in the L/W ratios between the specimens studied, n = number of spores measured from given number of specimens. Sections were studied at magnification up to ×1000 using a Nikon Eclipse E600 microscope and phase contrast illumination. Drawings were made with the aid of a drawing tube. Special colour terms are from Petersen (1996) and Anonymous (1969).

Description

Protomerulius efibulatus Y.C. Dai & Y.L. Wei, **sp. nov.** **Fig.1**

MycoBank MB 512016

Carpophorum annuum, resupinatum, facies pororum cremea vel bubalina; pori rotundi, 6–8 per mm. Systema hypharum dimiticum, hyphae generatoriae septatae, efibulatae; hyphae skeletales subiculi 2.5–3 µm in diam. Basidia longitudinaliter vel oblique septata, sporae ellipsoideae, hyalinae, IKI–, CB–, 4.3–5.5 × 2.5–3.3 µm.

Type. — **China.** Hainan Province, Lingshui County, Diaoluoshan Nature Reserve, on fallen angiosperm trunk, 21.XI.2007 *Dai 9378* (holotype in IFP).

Etymology — *Efibulatus* (Lat.): referring to the simple septa of generative hyphae.

Fruitbody — Basidiocarps annual, resupinate, difficult to separate from the substrate, soft corky when fresh, becoming corky upon drying, up to 4.5 cm long, 2.5 cm wide and 0.5 mm thick. Pore surface cream to pale buff, colour changed to pale brownish when bruised, almost unchanged upon drying; sterile margin very narrow; pores round, 6–8 per mm; dissepiments thin, entire when juvenile, lacerate with age. Context cream, corky, very thin, less than 0.2 mm thick. Tube layer concolorous with pore surface, up to 0.5 mm long.

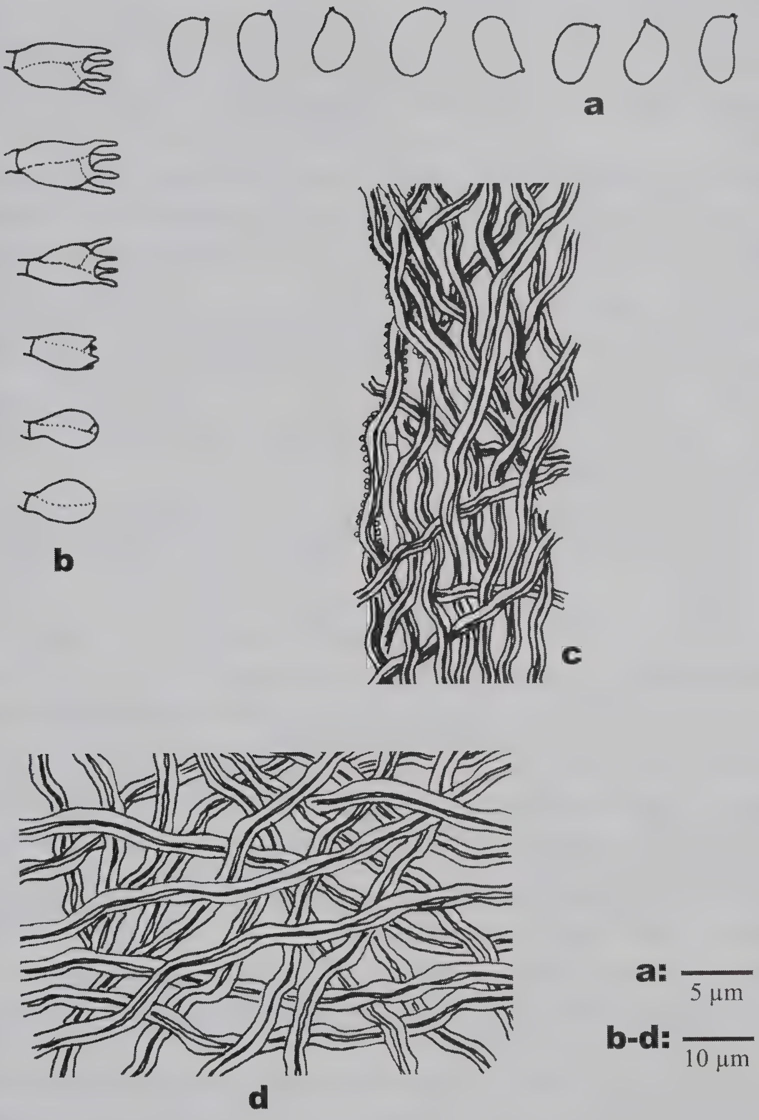

Fig. 1. Microscopic structures of *Protomerulius efibulatus* (drawn from the holotype). —a: Basidiospores. —b: Epibasidia and probasidia. —c: Hyphae from trama. —d: Hyphae from subiculum.

Hyphal structure — Hyphal system dimitic; generative hyphae bearing simple septa; skeletal hyphae dominant, thick-walled, rarely branched, IKI–, CB+; tissues unchanged in KOH.

Subiculum — Generative hyphae scanty, hyaline, thin-walled, occasionally branched, 2–3 µm diam.; skeletal hyphae dominant, hyaline, thick-walled with a narrow lumen to subsolid, flexuous, rarely branched, interwoven, 2.5–3 µm diam.

Tubes — Generative hyphae scanty, hyaline, thin-walled, rarely branched, 2–3 µm diam.; skeletal hyphae thick-walled with a narrow lumen to subsolid, flexuous, sometimes encrusted with granular crystals, rarely branched, tightly interwoven, 2–3.5 µm diam. Cystidia and cystidioles absent. Probasidia pyriform to subglobose, thin-walled, longitudinally or obliquely septate, 6–8.5 × 5.3–7.5 µm; epibasidia barrel-shaped, thin-walled, longitudinally septate, with four sterigmata and a simple septum at the base, 8–10 × 6–7 µm.

Spores — Basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, (4–)4.3–5.5(–6) × (2.1–)2.5–3.3(–3.6) µm, L = 4.98 µm, W = 2.97 µm, Q = 1.63–1.73 (n=66/2).

Additional specimen (paratype) examined. — **China.** Hainan Province, Ledong County, Jianfengling Nature Reserve, on rotten angiosperm wood, 19.XI.2007 *Dai 9322* (IFP).

Discussion

Previously three polypores, *Protomerulius brasiliensis, P. caryae* and *Elmerina borneensis*, shared characters of a poroid hymenophore, resupinate basidiocarps and longitudinally septate basidia. *Protomerulius brasiliensis* is distinguished from *P. efibulatus* by its large pores (1–2 per mm) and big basidiospores (6–6.5 × 4–5 µm, Bandoni et al. 1982). *Protomerulius caryae* differs from *P. efibulatus* by its greyish pores, allantoid basidiospores (4.9–6.2 × 2.2–2.8 µm, Niemelä 2005), and clamp connections on its generative hyphae. In addition, *P. caryae* occurs in temperate forests (Gilbertson & Ryvarden 1986, Ryvarden & Gilbertson 1993, Núñez & Ryvarden 2001).

Elmerina borneensis is different from *P. efibulatus* by its bigger pores (1–2 per mm) and bigger basidiospores (8–10 × 5–6 µm, Núñez 1998). In addition, its probasidia are clavate and aseptate.

Protomerulius and *Elmerina* were included previously in *Tremellales*, but recent phylogenetic studies showed both genera were closely related to *Auriculariales* rather than *Tremellales* (Weiβ & Oberwinkler 2001, Larsson et al. 2004). We did not make molecular study to indicate the phylogenetic relationships of the new species and other taxa in these two genera, such work will be done in the coming years.

Key to species of *Elmerina* and *Protomerulius*

1. Probasidia pyriform to subglobose, septate.................... 2 (*Protomerulius*)
1. Probasidia clavate, aseptate ....5 (*Elmerina*)

2. Generative hyphae with simple septa............................ *P. efibulatus*
2. Generative hyphae with clamp connections 3

3. Pores 3–4 per mm; basidiospores allantoid.......................... *P. caryae*
3. Pores 1–2 per mm; basidiospores ellipsoid or oval................................4

4. Gloeocystidia present; basidiospores oval.......................... *P. brasiliensis*
4. Gloeocystidia absent; basidiospores ellipsoid.......................*P. africanus*

5. Basidiocarps resupinate .... *E. borneensis*
5. Basidiocarps pileate 6

6. Hymenophore lamellate to almost daedalioid ....*E. holophaea*
6. Hymenophore poroid to partly lamellate 7

7. Basidiocarps dimidiate...8
7. Basidiocarps substipitate 9

8. Pores small, 6–8 per mm .... *E. dimidiata*
8. Pores big, 1–3 mm wide...*E. hexagonoides*

9. Basidiospores smaller, < 8 µm in length ....*E. substuppea*
9. Basidiospores bigger, > 8 µm in length 10

10. Hyphal pegs present; skeletal hyphae dominant..................*E. cladophora*
10. Hyphal pegs absent; generative hyphae dominant .... *E. unguliformis*

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Lepiota (Agaricaceae, Basidiomycota) species diversity in Israel

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Abstract — Species diversity for *Lepiota* in Israel is presented. The 18 *Lepiota* species recorded from Israel include *L. apatelia, L. brunneoincarnata, L. brunneolilacea, L. castanea, L. clypeolaria, L. cortinarius, L. echinella, L. erminea, L. forquignonii, L. helveola, L. ignivolvata, L. lilacea, L. locquinii, L. micropholis, L. oreadiformis, L. pallida, L. subgracilis*, and *L. subincarnata*. Eight species —*L. cortinarius, L. echinella, L. forquignonii, L. helveola, L. ignivolvata, L. locquinii, L. oreadiformis*, and *L. pallida* — are reported for the first time for Israel. Israeli locations and collection dates, habitat data, general distribution, and taxonomic remarks are provided for all species. Detailed macro- and micromorphological descriptions and illustrations are given for the eight species newly recorded from Israel.

Key words — Asia, biodiversity, ecology, *Lepioteae*, taxonomy

Introduction

Lepiota is one of the most problematic genera in the *Agaricaceae.* Traditional taxonomic classification in the genus is based on a very limited number of traits, such as spore shape and size, pileipellis structure, microchemical reactivity, and fruitbody habitus. An overview of current *Lepiota* systematics reveals a lack of taxonomic consensus regarding which infrageneric taxa to recognize and which traits are of infrageneric significance (Candusso & Lanzoni 1990, Wasser 1980, Migliozzi 1996). Molecular datasets suggest a need for total reorganization of current *Lepiota* systematics, which conflicts with phylogenetic relationships inferred from molecular analyses (Johnson & Vilgalys 1998, Johnson 1999, Vellinga 2003, 2004a). Nonetheless, we feel that extensive study of known taxa, especially those described from the tropics, is required prior to any serious taxonomic changes.

To date, approximately 500 species are included in the genus *Lepiota* (Candusso & Lanzoni 1990, Guzmán & Guzmán-Dávalos 1992, Kirk et al. 2001, Vellinga 2004b). The genus is almost cosmopolitan, with most species tropical and subtropical in distribution (Singer 1986). Nonetheless, although Vellinga (2004b) notes that *Leucoagaricus* and *Leucocoprinus* are more species rich in the tropics than in temperate regions, *Lepiota* does occur in relatively cold areas (high latitudes, high altitudes).

The genus *Lepiota* is not well studied in Israel. Fragmentary data on some *Lepiota* species is provided in papers devoted to *Agaricales* from Israel (Avizohar-Hershenzon 1968, Binyamini 1975, 1976, 1984; Didukh et al. 2002, Kosakyan et al. 2008). Prior to our current research only ten *Lepiota* species were reported for Israel: *L. apatelia*, *L. brunneoincarnata*, *L. brunneolilacea*, *L. clypeolaria*, *L. castanea*, *L. erminea*, *L. lilacea*, *L. micropholis*, *L. subgracilis*, and *L. subincarnata*. Our investigation now adds eight *Lepiota* species to the known Israeli mycobiota: *L. cortinarius*, *L. echinella*, *L. forquignonii*, *L. helveola*, *L. ignivolvata*, *L. locquinii*, *L. oreadiformis*, *L. pallida*. Of these, *L. apatelia*, *L. brunneolilacea*, *L. cortinarius*, *L. echinella*, *L. ignivolvata*, and *L. pallida*, are new reports for Asia.

Material and methods

The species-richness research on *Lepiota* species in Israel is based on (1) our fieldwork during 1995–2007 fruiting seasons; (2) a study of extensive material at the Tel Aviv University herbarium (TELA) in April 1991, and (3) a review of the published literature on the *Agaricales* of Israel. The material collected is kept at the Herbarium of the Institute of Evolution, University of Haifa (HAI, Israel).

Microscopic characteristics were observed using a Carl Zeiss-amplival microscope. Fungal material was mounted on a microscope slide and examined in water using a light/dark field microscope with or without phase contrast at ×20, ×40, and ×100 (oil immersion). For statistical calculations, 30 spores were measured for every preparation. Micromorphological characteristics of our specimens were observed using Melzer's reagent and Cresyl blue. General species distributions are given according to Wasser (1980), Moser (1983), Candusso & Lanzoni (1990), Guzmán & Guzmán-Dávalos (1992), and Vellinga (2001, 2004b). Distribution (Fig. 1) of species in Israel is given according to natural regions of Israel (Feinbrun-Dothan & Danin 1998).

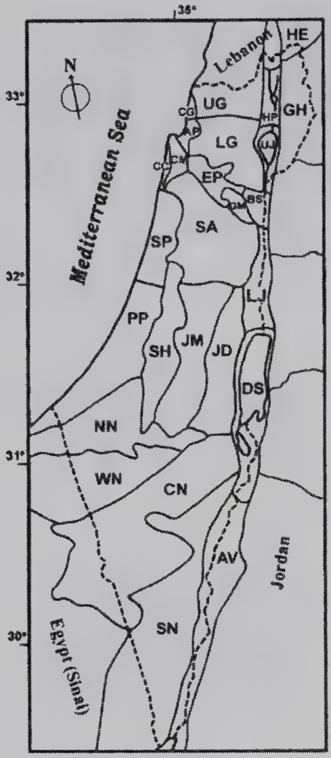


FIGURE 1. Natural regions of Israel: **AP** – Akko Plain; **AV** – Arava Valley; **BS** – Beit Shean Valley; **CC** – Carmel Coast; **CG** – Coast Galilee; **CM** – Carmel Mount; **CN** – Central Negev; **DS** – Dead Sea Area; **EP** – Esdraelon (Yizre'el) Plain; **GH** – Golan Heights; **GM** – Gilboa Mount; **HE** – Hermon Mount; **HP** – Hula Plain; **JD** – Judean Desert; **JM** – Judean Mts.; **LG** – Lower Galilee; **LJ** – Lower Jordan Valley; **NN** – Northern Negev; **PP** – Philistean Plain; **SA** – Samaria; **SH** – Shefela; **SN** – South Negev; **SP** – Sharon Plain; **UG** – Upper Galilee; **UJ** – Upper Jordan Valley; **WN** – Western Negev.

Taxonomy

The description of species diversity of genus *Lepiota* of Israel is presented below, including eight species new to Israel and a number new to Asia or Near East.

Genus *Lepiota*

(Pers.) Gray, A Natural arrangement of British plants 1: 601 (1821).

Lepiota differs from the closely related genus *Cystolepiota* mainly by structure of the common veil. Fundamental character differences separating *Lepiota* from the related *Macrolepiota* include fruitbody habitus, hymenophoral trama, spore wall composition, and structure of the common veil. From similar *Leucoagaricus* and *Leucocoprinus* the genus *Lepiota* differs in fruitbody habitus, spore wall composition, presence of clamp-connections (most species) and structure of the common veil. *Lepiota* is easily distinguished from *Chlorophyllum* by fruitbody habitus, structure of the common veil, and whitish lamellae (for green-spored *Chlorophyllum* species).

Section *Lepiota*

Lepiota clypeolaria (Bull.) P. Kumm., Führ. Pilzk.: 137. 1871. FIGURE 6

Descriptions and illustrations: Binyamini (1975: 147), Wasser (1980: 253–254), Candusso & Lanzoni (1990: 168–172, pl. 15), Vellinga (2001: 116–117).

HABITAT: Solitary or in small groups, saprotrophic on the soil, in the fields and broadleaf forests.

GENERAL DISTRIBUTION: Africa: Algeria, Morocco; Asia: Azerbaijan, China, Georgia, Israel, Mongolia, Russia, Sri Lanka, Turkey; Australia; Europe: Austria, Belgium, British Isles, Czech Republic, Denmark, Finland, France, Germany, Italy, Latvia, Lithuania, Poland, Russia, Serbia, Spain, Ukraine; North America: Canada, Cuba, Mexico, USA; South America: Chile.

MATERIAL EXAMINED: GH: Bar'am Wood, *Quercus* trees, 25.12.1972, leg. R. Neeman, det. M. Moser, rev. S.P Wasser & M. Didukh (TELA-NM-72.464); SP: Tel Aviv University, in grass, 19.04.1980, leg. & det. N. Binyamini, rev. M. Didukh, 20.03.2003 (TELA-NM-80.645).

NOTES: *Lepiota clypeolaria* is a polymorphic species. Modern species concepts vary according to author. For instance, Israeli specimens and descriptions of species from Ukraine (Wasser 1980) appear to differ from those from Netherlands (Vellinga 2001). Basic differences involve spore size, particularities of the fruit body, odor, and taste.

Lepiota cortinarius J.E. Lange, Dansk. Bot. Ark. 2(3): 25. 1915. FIGURES 2, 6

PILEUS 4–6 cm, conical when young, with inflexed margin, later applanate, with broad umbo, at centre tomentose, around centre breaking up into squamules. In young specimens squamules are brownish, later on around the center they are paler, on cream background, immature fruit bodies with whitish velar remnants at margin. LAMELLAE crowded, free from stipe, white to cream, with whitish flocculose edge. STIPE 4–5 × 0.4–1.0 cm, with almost 2 cm wide bulb at the base, hollow, whitish at apex, creamy-yellowish with few squamules below. CONTEXT whitish, with strong flour smell. SPORE PRINT whitish.

BASIDIOSPORES 6.5–9.0 × 3.0–4.0 µm, oblong ellipsoid, with lateral apiculus, dextrinoid, not metachromatic in Cresyl Blue. BASIDIA 4-spored, 15–30 × 5–8 µm, clavate. PLEUROCYSTIDIA absent. CHEILOCYSTIDIA 20–50 × 6–15 µm, mostly clavate or cylindrical-clavate. HYMENOPHORAL TRAMA regular. PILEIPELLIS composed by long elements, tapering in apex, with brownish pigment, mixed with basal short elements. STIPITIPELLIS composed by colorless cylindrical hyphae. CLAMP-CONNECTIONS present in all tissues.

HABITAT: Solitary to gregarious, saprotrophic on soil, in grasslands.

GENERAL DISTRIBUTION: Asia: Israel; Europe: Denmark, France, Germany, Greece, Lithuania, the Netherlands; North America: USA.

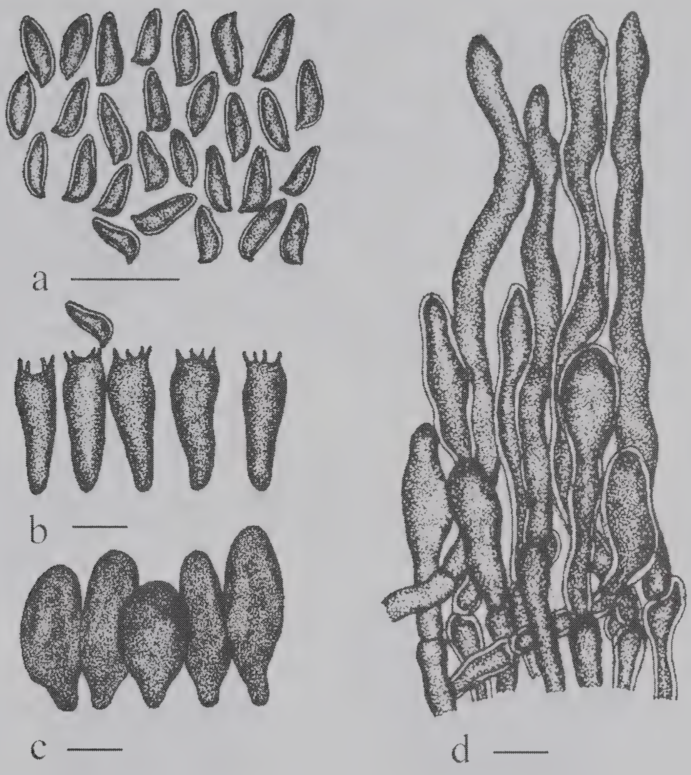


Figure 2. *Lepiota cortinarius* (HAI-525).
a – basidiomata, b – basidiospores, c – cheilocystidia. Bars = 10 µm.

Material examined: CM: Mt. Carmel National Park, in grass, 08.12.1994, leg. & det. S.P. Wasser (HAI-525).

Notes: *Lepiota cortinarius,* rare in Europe, is recorded here from Asia for the first time.

Lepiota erminea **(Fr.) P. Kumm., Führ. Pilzk.: 136. 1871.** Figure 6

=*Lepiota alba* (Bres.) Sacc., Syll. fung. 5: 37. 1887.

Descriptions and illustrations: Binyamini (1984: 60, as *Lepiota alba*), Candusso & Lanzoni (1990: 173–174, pl. 13a), Vellinga (2001: 118–119).

Habitat: Solitary to gregarious, in small groups, saprotrophic on the soil, in coniferous forests.

General distribution: Africa: Morocco; Asia: Georgia, Israel, Russia (Eastern Siberia), Turkey; Europe: Belarus, British Isles, Czech Republic, Denmark, France, Germany, Italy, Latvia, Lithuania, Poland, Spain.

Material examined: PP: Hadera, Iron wood, under *Pinus* sp. on the ground, 3.01.1978, leg. & det. N. Binyamini, rev. M. Didukh (TELA-NM-78.414).

Notes: *Lepiota erminea* is rare in Israel. Two names exist in the literature for a white species with fusiform spores: *L. erminea* and *L. alba*. The basic differentiating criteria are the raphanoid smell and longer spores of *L. erminea*. However, the latter trait is not very reliable, since *L. alba* spores vary significantly (Babos 1979). Furthermore, the overlap of spore dimensions of the two species — (12–)13–17(–20) × (5–)6–6.5(–7) µm in *L. alba* vs. (13–)15–18(–21) × 5–7 µm in *L. erminea* (Bon 1996) — can make separation of the two species even more difficult, as also demonstrated in Huijsman's (1943) and Vellinga's (2001) studies of Dutch material. As a result, Vellinga (2001) regards smell and spore size as insufficient to separate two species. The two species are currently referred to *L. erminea.*

Lepiota ignivolvata Bousset & Joss. ex Joss., Riv. Micol. 33(1): 30. 1948. Figures 3, 6

Pileus 3–4.5 cm, with slightly umbonate brown centre, around centre with brownish squamules on pale background. Lamellae free, crowded, white to cream colored. Stipe 4–5 × 0.5–1.5 cm, with brown narrow ring, whitish cream, discoloring orange when touched. Context white to creamy; smell strong, like the rubber smell of *L. cristata* (Bolton) P. Kumm. Spore print white.

Basidiospores 8.0–11(–13) × 5.0–6.5 µm, amygdaliform, with fluorescent content, dextrinoid, not metachromatic in Cresyl Blue. Basidia 4-spored, 20–25(–30) × 6–8 µm, clavate. Pleurocystidia absent. Cheilocystidia 15–35 × 8.0–15 µm, clavate. Pileipellis composed by long, brownish erect elements 70–300 µm, mixed with rather short ones. Clamp-connections present.

Habitat: Solitary or in small groups, saprotrophic on soil, in grasslands.

General distribution: Asia: Israel; Europe: Denmark, France, Germany, Italy, Luxemburg, Switzerland.

Material examined: CM: Mt. Carmel, Haifa University, National Park, in grass, 17.12.2000, leg. & det. S.P Wasser (HAI-SP-19).

Notes: *Lepiota ignivolvata* is recorded for the first time in Israel. It is also a new species for Asian mycobiota. By habitus and smell it is similar to *L. cristata.* It differs from the latter by distinct ring and shape of spores (truncate and narrowly triangular in *L. cristata*). Not edible.

Lepiota oreadiformis Velen., České Houby 1: 215. 1920. Figures 4, 6

Pileus 2–5 cm in diam., thin-fleshed, convex, plano-convex later on, with umbo, yellowish-fulvous, skin-colored, darker in the center, paler towards the margin, covered with slight flake like pruina in young fruit bodies, without pruina later on; edge at first involute, straight and wavy later on. Lamellae

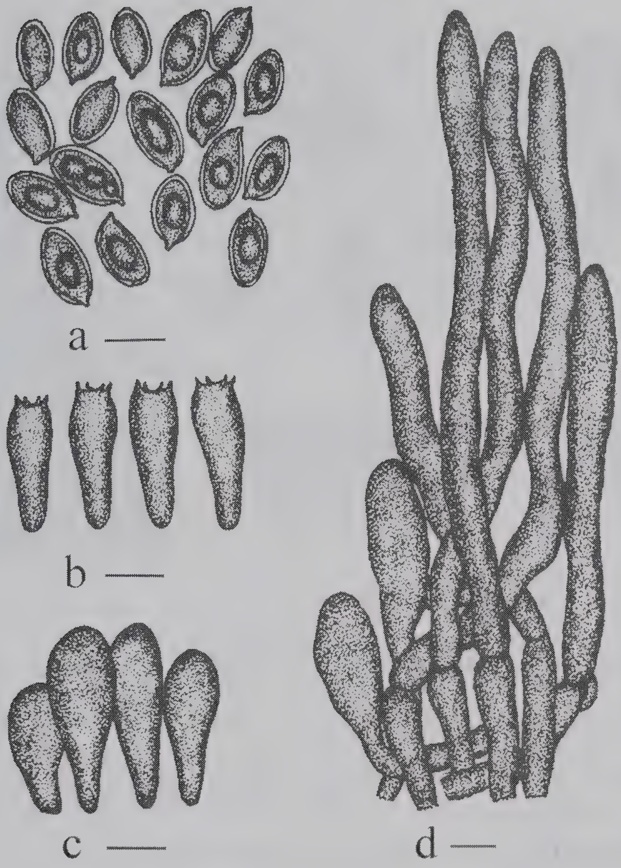


Figure 3. *Lepiota ignivolvata* (HAI-SP-19).
a – basidiospores, b – basidia, c – cheilocystidia, d – elements of the pileipellis. Bars = 10 µm.

free, thin, white, later on with an ochroid tint. Stipe 2.5–7 × 0.2–0.4 cm, central, cylindrical, often slightly curved, fistulose in the center, whitish in the upper part, concolorous with the pileus towards the base, covered with slightly flake below the ring. Ring whitish, evanescent. Context white, getting pale-fulvous tint below cuticle and in the base of the stipe. Spore print white.

Basidiospores 11.5–14 × 4.5–5.5 µm, ellipsoid-amygdaloid, with lateral apiculus, with one or some fluorescent drop or without it. Basidia 4-spored, 35–45 × 10–11 µm, cylindrical-clavate, clavate. Pleurocystidia absent. Cheilocystidia 12–34 × 5–13 µm, narrowly clavate, narrowly utriform, some with a thickened wall. Hymenophoral trama regular. Pileipellis

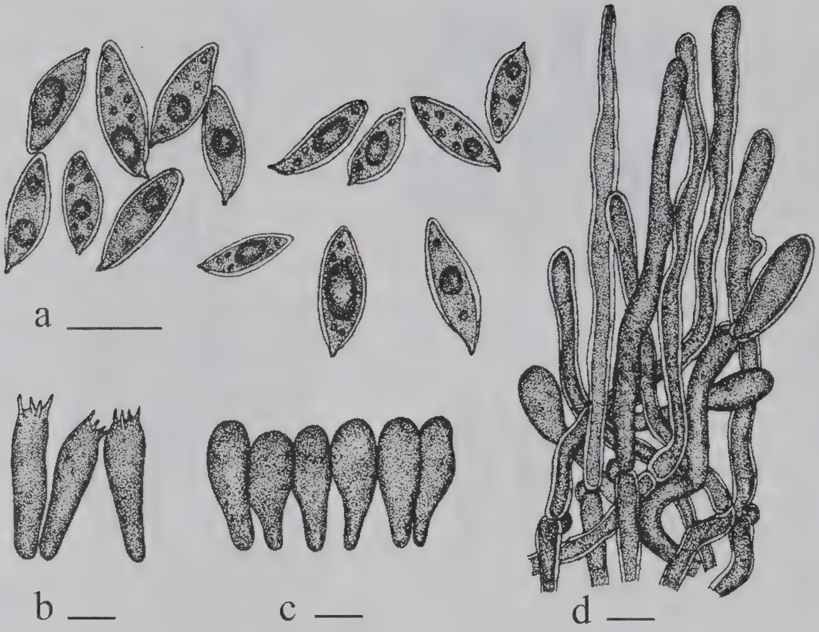


Figure 4. *Lepiota oreadiformis* (HAI-529).
a – basidiospores, b – basidia, c – cheilocystidia, d – elements of the pileipellis. Bars = 10μm.

composed by erect elements, 50–150 × 5–12 μm, sometimes mixed with short clavate elements, often both type of elements are brown colored. Stipitipellis composed by 5–10 μm wide cylindrical yellowish elements. Clamp-connections present.

Habitat: Solitary or in small groups, saprotrophic on soil, in grasslands.

General distribution: Asia: Azerbaijan, Israel, Russia (Eastern Siberia), Turkey; Europe: British Isles, Estonia, France, Germany, Lithuania, Russia, the Netherlands.

Material examined: SP: Ramat Gan, in grassland, 06.02.2002, leg. & det. S.P Wasser & M. Didukh. (HAI-529). **Figure 5**

Notes: *Lepiota oreadiformis* is recorded for the first time for Israel mycobiota. It is close to *L. pallida*, which has septate pileipellis elements (Candusso & Lanzoni 1990). Vellinga (2001) notes that a more yellowish coloration and smaller sized spores distinguish dark specimens of *L. erminea* from *L. oreadiformis*. Sometimes, *L. oreadiformis* may be confused with young specimens of *L. clypeolaria,* which produces similar spores. *L. clypeolaria* can be differentiated by a pileus cuticle that splits up in the distinct central disc surrounded by discrete squamules in contrast to *L. oreadiformis* characterized by an evenly colored pileal surface that uniformly splits up into small patches (Vellinga 2001).

Lepiota pallida Locq. ex Bon & Candusso,
in Candusso & Lanzoni, *Lepiota* s.l. Fungi Europaei 4: 182. 1990. FIGURES 5–6

PILEUS 0.8–1.9 cm in diam., very thin-fleshed (0.5–1.0 mm), hemispheric, later plano-convex, with a small umbo, dark brown in the center, pale-brown, whitish-ochre, brownish-red towards the margin, scaly-flaked, scales formed by bundles of brownish and whitish hairs, coarse-fibrillose, dry with straight, slightly fringed edge, often bearing velar remnants. LAMELLAE free, thin, crowded, with an even edge, white, pale cream on drying. STIPE 2–4 × 0.2–0.3 cm, central, straight, sometimes slightly curved, thickened towards the base, fistulose, whitish, smooth, covered with whitish-ochre pruina up to half of the stipe. RING evanescent. CONTEXT thin, white, unchanging on autooxidation, without a particular taste or odor. SPORE PRINT white.

BASIDIOSPORES 11.5–14.5 × 4.5–5.5 µm, ellipsoid-amygdaloid, fusiform, with lateral apiculus, with slight suprahilar depression, with or without one-two fluorescent drops, smooth, thin-walled, dextrinoid, not metachromatic in Cresyl Blue. BASIDIA 4-spored, 24–32 × 6–7 µm, clavate. PLEUROCYSTIDIA absent. CHEILOCYSTIDIA 20–37 × 5–7 µm, clavate or fusiform. HYMENOPHORAL TRAMA regular. PILEIPELLIS consisting of obtuse or nearly cylindrical septate hyphae 3–6 µm in diam., long, not septate elements,150–250 × 5–10 µm are also present. CLAMP-CONNECTIONS present.

HABITAT: Mostly in small groups, saprotrophic on soils, in broadleaf forests.

GENERAL DISTRIBUTION: Africa: Morocco; Asia: Israel; Europe: France, Hungary, Italy, Ukraine.

MATERIAL EXAMINED: PP: Hadera, under *Eucalyptus*, on the ground, in groups, 10.03.2002, leg. S.P. Wasser, det. M. Didukh (HAI-530).

NOTES: *Lepiota pallida* is new for Israel and Asian mycobiota. This species, one of the smallest *Lepiota* species, is rare throughout the world and previously known from six localities in Europe and one in North Africa (Locquin 1945, Kühner & Romagnesi 1953, Babos 1969, Malençon & Bertault 1970, Wasser 1975). Our finding is the eighth report of this rare species. Wasser (1980) has observed that *L. pallida* is found mostly in arid habitats.

In his original diagnosis, Locquin (1945) did not indicate cystidia; his name, which was invalid due to the incomplete Latin description, was later validated by Candusso & Lanzoni (1990). Although Hungarian specimens of *L. pallida* collected by Babos (1969) also lack cystidia, Ukrainian (Wasser 1980), Italian (Candusso & Lanzoni 1990), and Israeli specimens have cheilocystidia.

The habitat of the species differs depending on the country studied. In Italy and France it grows under *Cedrus* and *Robinia pseudoacacia* (Candusso & Lanzoni 1990), in Ukraine it grows in *Pinus* forest and under *Robinia pseudoacacia* (Wasser 1980); in Israel, under *Eucalyptus* tree. Morphologically,

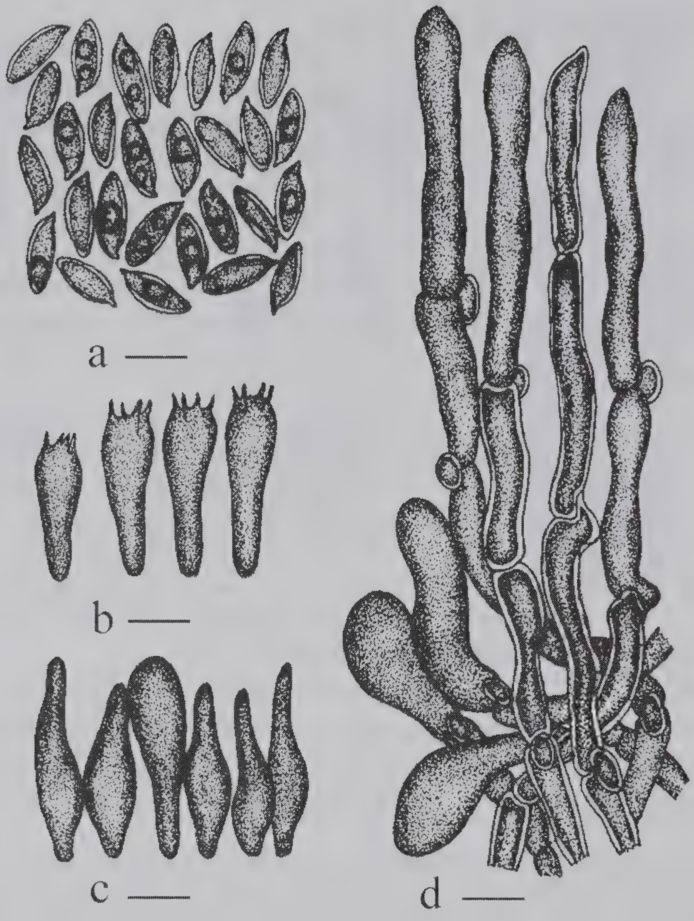


Figure 5. *Lepiota pallida* (HAI-530).
a – basidiospores, b – basidia, c – cheilocystidia, d – elements of the pileipellis. Bars = 10μm.

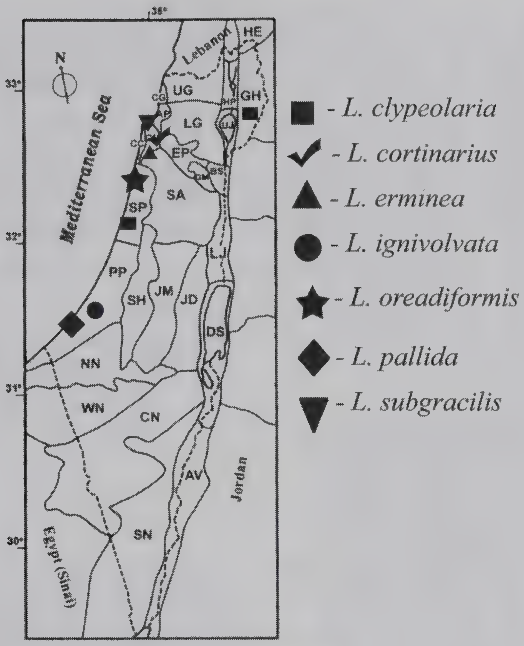
the species resembles small representatives of *Lepiota clypeolaria* and *L. oreadiformis*. From the latter species it differs mostly in septate pileus covering elements.

Lepiota subgracilis Kühner, Bull. Soc. mycol. France 52: 231. 1936. Figure 6

Description and illustration: Kosakyan et al. (2008: 66–68).

Habitat: Solitary or in small groups, saprotrophic on the soil, in coniferous forests.

General Distribution: Asia: Israel, Russia (Far East-Primorye Territory), Sri Lanka, Turkey; Europe: British Isles, Czech Republic, France, Hungary, Italy, the Netherlands, Ukraine; North America: USA; South America: Argentina.


35°
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Mediterranean Sea
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DS
NN
WN
CN
AV
SN
Jordan
Egypt (Sinai)
■ - L. clypeolaria
✓ - L. cortinarius
▲ - L. erminea
● - L. ignivolvata
★ - L. oreadiformis
◆ - L. pallida
▼ - L. subgracilis

FIGURE 6. The distribution of representatives of section *Lepiota* in Israel.

MATERIAL EXAMINED: Israel. CM: Ramat Hanadiv, in *Pinus* stand, leg. Y. Ur, 19.02.2007, det. A. Kosakyan (HAI 328).

NOTES: *Lepiota subgracilis* is a relatively common species. For Israel it is recorded for first time (Kosakyan et al. 2008). *L. subgracilis* is a quite variable species. Our specimens differ from those described in Wasser (1980) in producing smaller pilei and larger, more variable cystidia. Candusso & Lanzoni (1990) describe specimens with smaller spores, while Vellinga (2001) gives larger pileus, stipe, and spore sizes and shorter, narrower pileipellis hyphae for *L. subgracilis.*

Section *Ovisporae* (J.E. Lange) Kühner

Lepiota brunneoincarnata Chodat & C. Martín,
Bull. Soc. Bot. Genève, 2 sér. 5: 222. (1889). FIGURE 11

Descriptions and illustrations: Binyamini (1975: 149), Wasser (1980: 248–252), Candusso & Lanzoni (1990: 248–252), Vellinga (2001: 127).

HABITAT: Gregarious or more rarely solitary, saprotrophic on soil, in parks, grasslands, coniferous and broadleaf forests.

GENERAL DISTRIBUTION: Africa: Algeria, Morocco; Asia: Azerbaijan, India, Israel; Europe: Austria, British Isles, Czech Republic, Denmark, Estonia, France, Germany, Poland, Sweden, Switzerland, the Netherlands, Ukraine.

Distribution in Israel: SP: Hadera, under *Eucalyptus* trees, 14.12.1972, leg. & det. N. Binyamini (TELA-NM 72.348); Tel Aviv, Hayarqon Park, under *Cupressus* tree, 25.02.1973, leg. & det. N. Binyamini (TELA-N. 73.168); Ilanot, on lawn, 28.09.1978, leg. & det. N. Binyamini (TELA-N. 78.348); Tel Aviv, Rosh-Ha'ayin Park, on lawn, under *Eucalyptus* trees, 18.12.1989, leg. N. Binyamini and A. Prusbul, det. N. Binyamini (TELA-N. 89.276).

Material examined: CM: Mt. Carmel, Haifa University National Park, on grass, 19.12.2000, leg. S. Tovbin, det. S.P. Wasser (HAI-SP-517); Mt. Carmel, Nahal Nesher, park, under *Casuarina* sp. 12.04.2003, leg. S.P. Wasser, det. M. Didukh (HAI- 524).

Notes: *Lepiota brunneoincarnata* is a very toxic species. It is known to contain high level of amatoxins. It contains α- and γ-amanitins — up to 3.5mg/g; a lethal dose for humans is approximately 50 to 300g of fresh mushroom (Meunier et al. 1995).

Lepiota brunneolilacea Bon & Boiffard,
Bull. trimest. Soc. mycol. France 88: 18 (1972). **Figure 11**

Descriptions and illustrations: Candusso & Lanzoni (1990: 252–255), Courtecuisse & Duhem (1994: 224, fig. 687), Didukh et al. (2002: 44).

Habitat: Solitary or in small groups, saprotrophic on soil, in parks, in *Pinus* groves.

General distribution: Asia: Israel; Europe: France, Italy, Spain, the Netherlands, Ukraine; North America: Canada.

Material examined: CM: Mt. Carmel National Park, Haifa University, under *Pinus halepensis,* 20.12.2001, leg. K. Tzukor, det. M. Didukh (HAI SP-17).

Notes: *L. brunneolilacea* was described by Bon & Boiffard (1972) from the Atlantic and Mediterranean coasts of France, growing on dunes amid *Ammophila arenaria*. This species is new for Asian mycobiota.

Lepiota echinella Quél. & G.E. Bernard, Bull. Soc. mycol. France 4: pl. 1, fig. 2 (1888). **Figures 7, 11**

Pileus 1.5 cm in diam., thin-fleshed, hemispheric, later on convex-plane, with a small umbo, brownish-reddish on white background, covered with uplifted scales, thin, edge involute, wavy. Lamellae free, thin, crowded, white, with an uneven eroded concolorous edge. Stipe 2–4 × 0.1–0.2 cm, central, pinkish, covered with darker colored fibrils, brownish at the base, with floccose-scaly pruina. Ring brownish, disappears at early stages, leaving a nearly indiscernible zone. Context white, slightly browning on autooxidation, without particular odor. Spore print whitish.

Basidiospores 5–6.5 × 3.5–4 µm, ellipsoid, with fluorescent content, weakly dextrinoid, not metachromatic in Cresyl Blue. Basidia 4-spored, 20–23 × 6–7 µm, clavate. Pleurocystidia absent. Cheilocystidia vary in shape: fusiform,

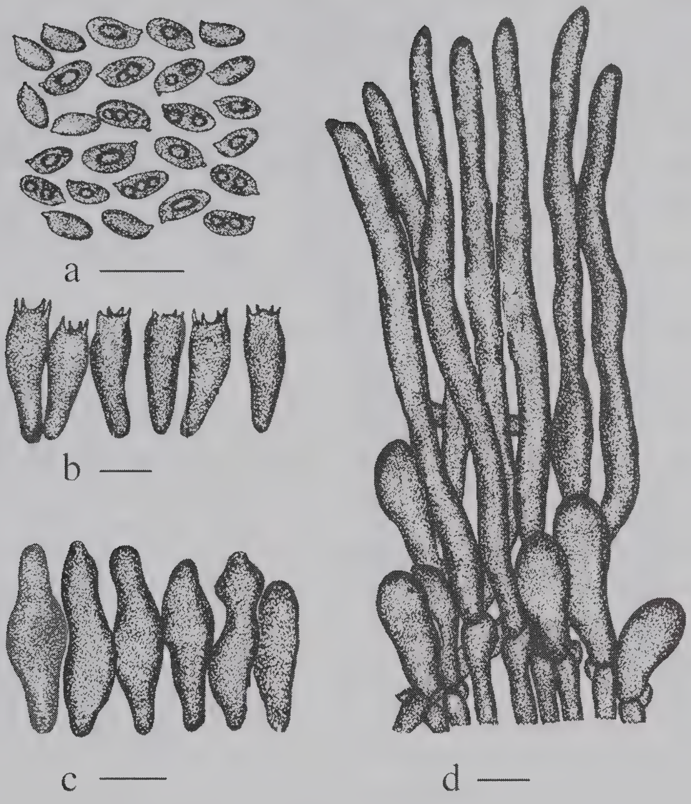


FIGURE 7. *Lepiota echinella* (HAI-M-528).
a – basidiospores, b – basidia , c – basidia, d – cheilocystidia, e – elements of the pileipellis.
Bars = 10μm.

lageniform, utriform, thin-walled, hyaline, 20–25 × 6–8 μm. HYMENOPHORAL TRAMA regular. PILEIPELLIS composed of erect, long, cylindrical brownish elements and short, narrowly clavate to cylindrical elements 15–50 × 5–12 μm. STIPITIPELLIS composed of narrow cylindrical hyphae, sometimes with a brown pigment. CLAMP-CONNECTIONS present in all tissues.

HABITAT: Gregarious in small groups, saprotrophic on soils, in grasslands.

GENERAL DISTRIBUTION: Africa: Morocco; Asia: Israel; Europe: British Isles, Czech Republic, Denmark, France, Germany, Hungary, Italy, Poland, the Netherlands, Ukraine.

MATERIAL EXAMINED: SP: Ramat-Gan, park, on the lawns, 28.03.2003, leg. Y. Ur, det. M. Didukh (HAI-M-528).

Notes: *Lepiota echinella* is a rare species in European countries. It is recorded for the first time in Israel. Vellinga (2001) notes that *L. lepida* Guinb. & M. Bodin comes very close to *L. echinella*, with its spores being slightly bigger and cheilocystidia more variable in size and shape in *L. echinella. L. locquinii* is likewise similar but can be differentiated by its smaller pileus and differently shaped cheilocystidia (clavate in *L. locquinii* and lageniform or utriform in *L. echinella*).

Lepiota forquignonii Quél.,
Compt. Rend. Assoc. Franç. Avanc. Sci. 13: 277. (1885). **Figures 8, 11**

Pileus 1–4 cm in diam., thin-fleshed, hemispherical, campanulate when young, later applanate with an obtuse umbo, dark grey, smooth in the center; apart from the central calotte the cuticle is broken up into variously shaped, grayish, brownish, adpressed, concentric squamules on the white background, radially fibrillose towards the margin; edge involute, thin. Lamellae free, ventricose, not very crowded, thick, with white eroded edge. Stipe 2.5–5 × 0.4–0.6 cm, cylindrical or tapering towards the apex, slightly widening towards the base, whitish, pale grayish-greenish, without a ring, covered with pale fulvous fibrils in the lower part, broadly fistulous. Context cotton-like, whitish, pale pink in stipe and pileus. Odor unpleasant, as in *L. cristata.* Spore print whitish.

Basidiospores 6–8 × 3.0–5 μm, oval, slightly dextrinoid, not metachromatic in Cresyl Blue. Basidia 4-spored, 14–20 × 6–8 μm, clavate, two-spored basidia can occur closer to the edge of the gills. Pleurocystidia absent. Cheilocystidia numerous, collected in bundles, variously shaped, 20–32 × 4.5–8.0 μm, nearly cylindrical, narrowly fusiform, narrowly clavate, some are capitate; with clamp-connections at the base. Hymenophoral trama regular. Pileipellis composed by long erect elements 80–400 × 5–10 μm in diam., collected in bundles, mostly thick-walled, with yellowish parietal pigment, tapering towards the apex, with slightly fusiform base, with clamps at the base of some elements; few narrowly clavate elements 24–28 × 7.2–10 μm occur among long elements. Stipitipellis composed by narrow cylindrical hyphae 3.0–5.0 μm wide. Clamp-connections present in all tissue.

Habitat: In small groups, saprotrophic on soil, in broadleaf forests.

General distribution: Africa: Morocco; Asia: Israel, Turkey; Europe: Italy, Sweden, the Netherlands; North America: USA; South America: Brazil.

Material examined: SP: Hadera, park, under *Eucalyptus* sp., on the ground, 09.12.2004, leg. Y. Ur, det. M. Didukh (HAI-520).

Notes: *Lepiota forquignonii* is new species for Israel. It is uncommon in Europe, where it is known primarily from the temperate regions and only rarely found in the warmer regionss (Vellinga 2001). In view of this, the finding of

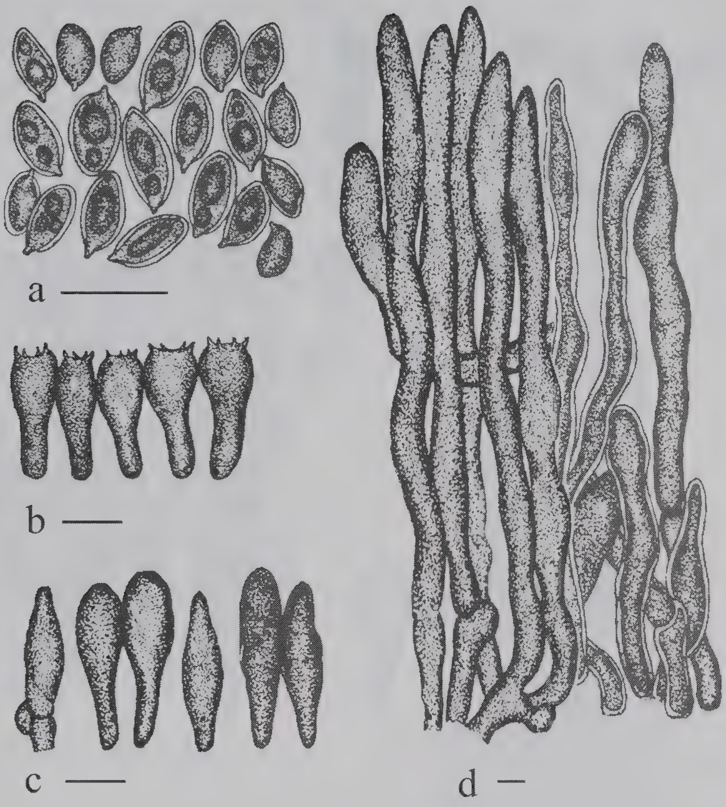


FIGURE 8. *Lepiota forquignonii* (HAI-520).
a – basidiospores, b – basidia, c – basidia, d – cheilocystidia, e – elements of the pileipellis.
Bars = 10µm.

L. forquignonii in warmer Israeli climate contributes to the knowledge about adaptive abilities of the species.

Lepiota helveola Bres., Fung. trident. 1(1): 15. 1882 ('1881'). FIGURES 9, 11

PILEUS 1.5–4 cm in diam., thin-fleshed, hemispheric, plano-convex or applanate later on, with a broad umbo, dirty grayish-pinkish, grayish-reddish, reddish-ochraceous-brownish, slightly fibrillose, covered with adpressed tiny dark squamules, between which white flesh can be seen; edge thin, involute, later on straight, wavy, often cracked. LAMELLAE free, thin, white, with a yellowish tint later on. STIPE 2–4(5) × 0.3–0.8 cm, central, cylindrical, fistulose, concolorous with the pileus or paler, smooth above the ring, with flake-like pruina below

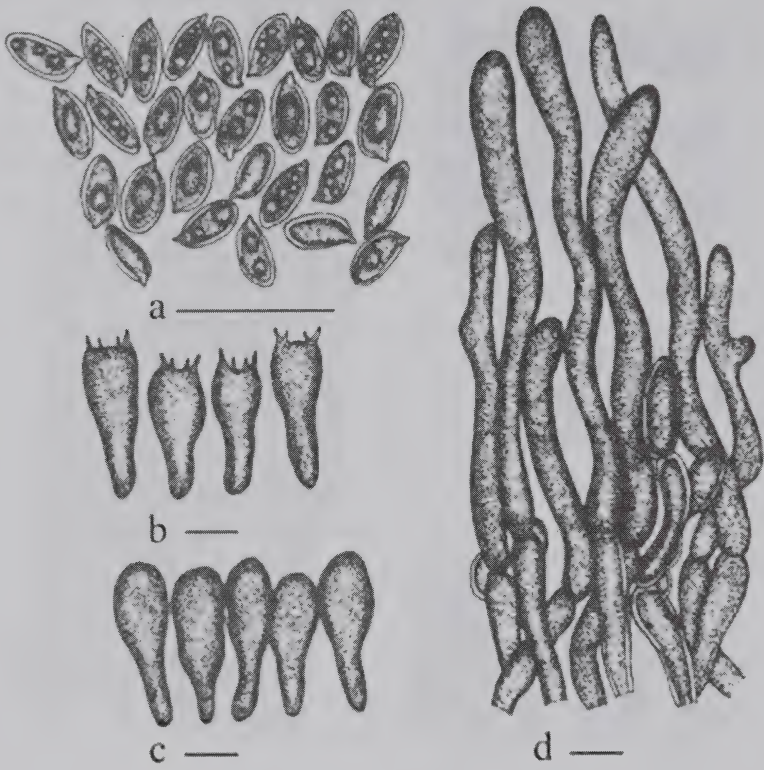


Figure 9. *Lepiota helveola* (HAI-531).
a – basidiospores, b – basidia, c – basidia, d – cheilocystidia, e – elements of the pileipellis.
Bars = 15µm.

the ring. Ring upper, funnel-shaped, whitish on the upper side, with lower side concolorous with the pileus. Context white, peripheral layer turns red on autooxidation, without a particular taste or odor. Spore print white.

Basidiospores 7–8 × 3.5–4 µm, colorless, ellipsoid, with lateral apiculus and fluorescent contents. Basidia 4-spored, 25–32 × 8–10 µm, clavate. Pleurocystidia absent. Cheilocystidia 28–34 × 8–11 µm, narrowly clavate. Hymenophoral trama regular. Pileipellis composed by clavate long elements 50–100 × 10–20 µm, with pigmentation in walls and at the base, mixed with rather short elements. Clamp-connections present.

Habitat: Solitary or in small groups in open areas, in coniferous forests.

General distribution: Africa: Algeria, Morocco; Asia: Azerbaijan, Israel, Japan; Europe: Czech Republic, France, Italy, Portugal, Spain, Ukraine.

Material examined: GH: Banias, under *Pinus halepensis*, 26.01.2003, leg. & det. S.P. Wasser & M. Didukh (HAI-531).

Notes: *Lepiota helveola* is a very rare species in Israel. Binyamini (1975), who first reported *L. helveola* for the country, did not provide information on the collection site or where the dried specimens were deposited. Poisonous.

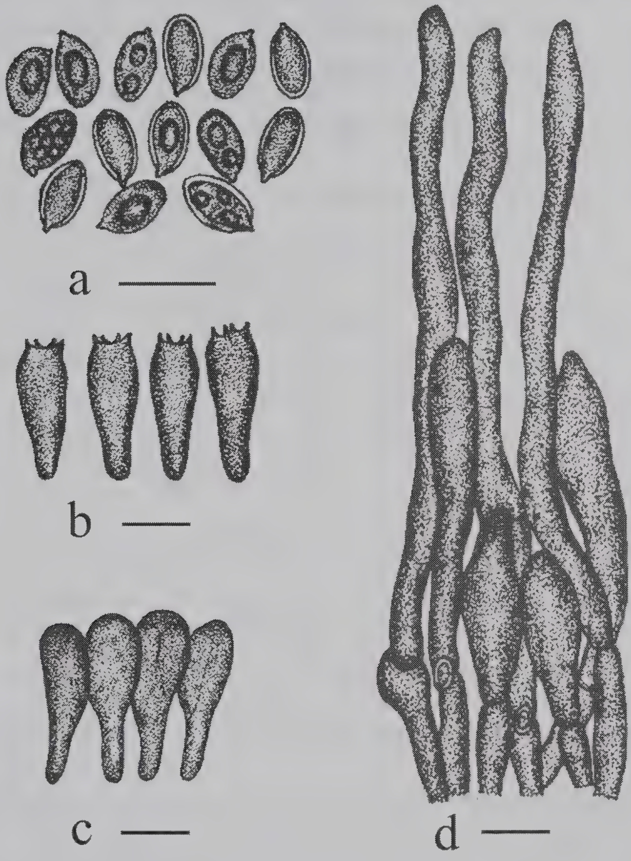


Figure 10. *Lepiota locquinii* (HAI-518).
a – basidiospores, b – basidia, c – basidia, d – cheilocystidia, e – elements of the pileipellis.
Bars = 10µm.

Lepiota locquinii Bon, Doc. Mycol. 16(61): 20. 1985. Figures 10–11

Pileus 1–1.5 cm in diam., thin-fleshed, hemispheric, with a small dark brown umbo, covered with scales formed upon cuticle breaking; with involuted, wavy. Lamellae free, thin, crowded, white-cream, with an uneven eroded concolorous edge. Stipe 1.5–2 × 0.1–0.2 cm, central, creamish-pinkish, covered with few fibrils, brownish-reddish at the base. Ring disappears at early stages. Context white, without any particular odor. Spore print whitish.

Basidiospores 7.5–9 × 4.5–5 µm, colorless, ellipsoid, with fluorescent context, weakly dextrinoid, not metachromatic in Cresyl Blue. Basidia 4-spored, 20–23 × 6–7 µm, clavate. Pleurocystidia absent. Cheilocystidia 18–25 × 5–8 µm, mostly clavate. Hymenophoral trama regular. Pileipellis composed by erect, long, cylindrical elements 50–100(150) × 8–10, with some narrowly clavate to cylindrical elements at the base. Stipitipellis composed by narrow cylindrical hyphae, sometimes with brown pigment. Clamp-connections present in all tissues.

Habitat: Gregarious, in broadleaf and coniferous forests, on humus-rich soils.

General distribution: Europe: Italy, France; Asia: Israel.

Material examined: CM: Mt. Carmel, near Nahal Oren, in mixed wood of *Pinus* and *Quercus*, 25.12.1996, leg. & det. S. P. Wasser (HAI-518).

Note: *Lepiota locquinii* is very rare worldwide and recorded here for the first time from Israel and Asia. *L. locquinii* is very similar to *L. echinella*, from which it can be differentiated by its smaller, paler pileus and differently shaped cheilocystidia (clavate in *L. locquinii* and lageniform to utriform in *L. echinella*).

Lepiota subincarnata J.E. Lange, Fl. Agaric. Danic. 5(Append.): v. 1940. Figure 11

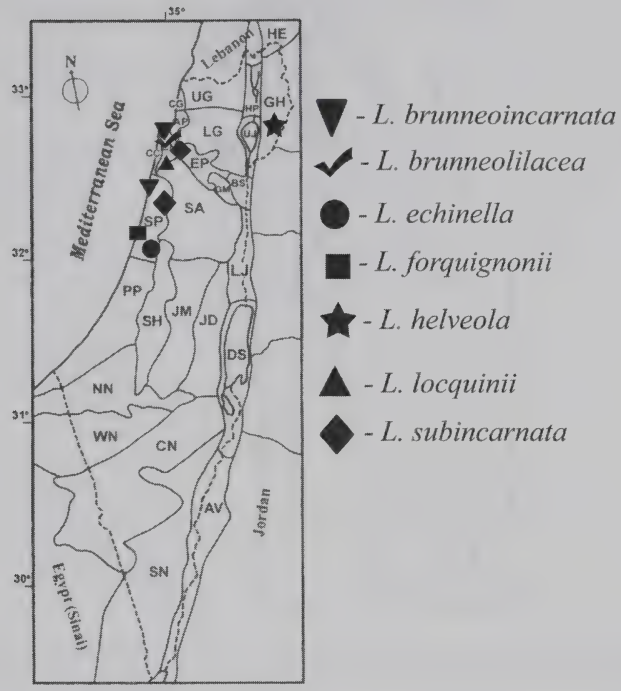
Descriptions and illustrations: Binyamini (1976: 70), Candusso & Lanzoni (1990: 244–247, pl. 25a), Vellinga (2001: 127).

Habitat: Gregarious, in small groups, saprotrophic on soils, in city-parks, gardens, in broadleaf forests.

General distribution: Asia: Israel, Turkey, Europe: France, Germany, Italy, Poland; North America: USA.

Material examined: SP: Hadera, Iron wood, mixed forest of *Quercus* and *Pinus* trees, 18.12.1973, leg. & det. N. Binyamini, rev. M. Didukh & S.P Wasser (TELA-N. 73.293); Tel Aviv, Hayarqon Park, on lawn, 26.02.1974, leg. & det. N. Binyamini, rev. M. Didukh & S.P. Wasser (TELA-N. 74.435); Miqwe-Yisra'el, under *Eucalyptus* sp., leg. & det. N. Binyamini, 10.12.1974, rev. M. Didukh & S.P. Wasser (TELA-N. 16.182); Hadera Park, under *Eucalyptus*, on the ground, 09.01.2004, leg. Y. Ur, det. M. Didukh (HAI-521); CM: Mt. Carmel, Carmel National Park, on grass, date 15.01.2003, leg. & det. S.P. Wasser (HAI- SP-23).

Notes: *Lepiota subincarnata* is not common in Asia, but has been found in Israel several times. This very toxic species contains amanitins (Bresinsky & Besl 1990).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AV
Jordan
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Egypt (Sinai)
▼ - L. brunneoincarnata
✓ - L. brunneolilacea
● - L. echinella
■ - L. forquignonii
★ - L. helveola
▲ - L. locquinii
◆ - L. subincarnata

Figure 11. The distribution of representatives of section *Ovisporae* in Israel.

Section *Stenosporae* (J.E. Lange) Kühner

Lepiota castanea Quél.,
Compt. Rend. Assoc. Franç. Avanc. Sci. 9: 661. 1881. Figure 12

Descriptions and illustrations: Binyamini (1984: 60), Candusso & Lanzoni (1990: 198–202), Vellinga (2001: 130–131).

Habitat: Solitary to gregarious, saprotrophic on soil, in coniferous forests.

General distribution: Africa: Morocco; Asia: Armenia, Azerbaijan, Israel, Japan, Russia, Turkey; Europe: British Isles, Czech Republic, Denmark, France, Germany, Italy, Latvia, Lithuania, Poland, Russia, the Netherlands; New Guinea.

Material examined: PP: Hadera, under *Pinus* sp., Wadi Ara, Iron Wood, 16.01.1979, leg. student, det. N. Binyamini, rev. S.P. Wasser & M. Didukh (TELA-N. 79.188).

Notes: *Lepiota castanea*, which is a rare in Israel, possesses medical properties. *L. castanea* exhibits antitumor activity against Sarcoma 180 and Ehrlich carcinoma at different inhibition rates (Ohta et al. 1998).

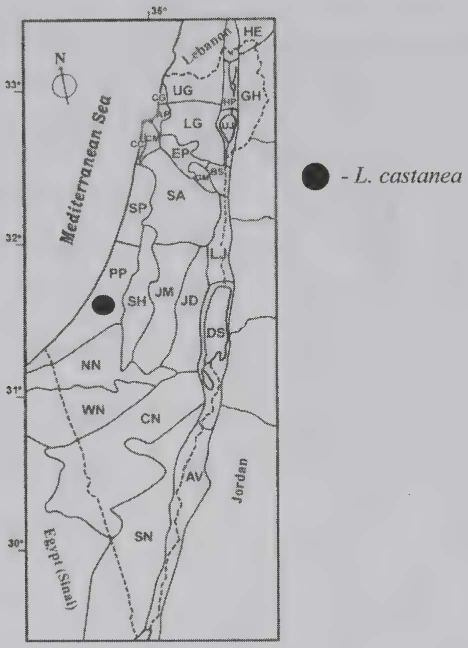


Figure 12. The distribution of representatives of section *Stenosporae* in Israel.

Section *Cristatae* Kühner ex Wasser

Lepiota apatelia Vellinga & Huijser, Belg. J. Bot. 131: 196. 1999 ('1998'). Figure 13

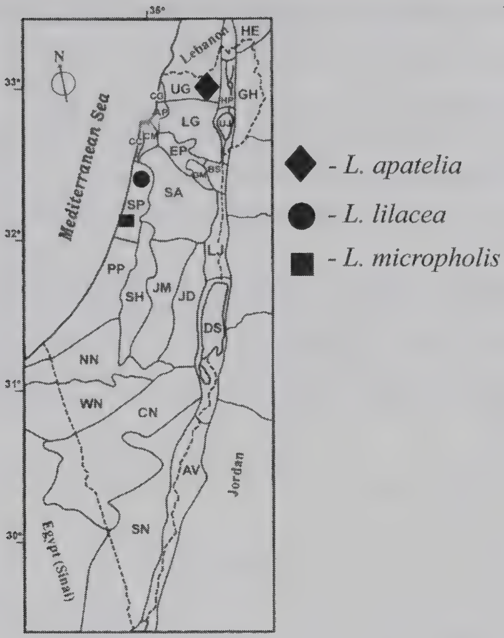
Description and illustration: Kosakyan et al.(2008: 59–74).

Habitat: Gregarious, often in big groups, saprotrophic on soil, in broadleaf forests.

General distribution: Asia: Israel; Europe: Austria, Germany, Italy; the Netherlands.

Material examined: UG: Safsufa forest, under *Quercus calliprinos*, leg. Y. Ur, 19.11.2006, det. A. Kosakyan (HAI 33).

Notes: *L. apatelia* is a very rare species that was described recently from the Netherlands by Vellinga & Huijser (1999). It is new species for Israel and for Asian mycobiota (Kosakyan et al. 2008). *L. apatelia* is macroscopically very similar to *L. cristata*, from which it is easily distinguished by basidiospore shape, absence of distinct annulus, and different smell. It is also very close to *L. cristatoides* Einhell., from which it differs by uneven and orange-brown pileus, absence of annulus, fruitbody size, and spore microchemical reactivity (Vellinga & Huijser 1999; Vellinga 2001). The similar *Lepiota thiersii* Sundb., described from California (Sundberg 1989), can be differentiated by spores that



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DS
NN
WN
CN
AV
Jordan
SN
Egypt (Sinai)
◆ - L. apatelia
● - L. lilacea
■ - L. micropholis

FIGURE 13. The distribution of representatives of section *Cristatae* in Israel.

are not dextrinoid, a less well-developed partial veil, possession of clavate to sphaeropedunculate pileipellis elements, and a farinaceous odor (Vellinga & Huijser 1999).

Lepiota lilacea Bres., Fung. trident. 2(8–10): 3. 1892. FIGURE 13

Descriptions and illustrations: Binyamini (1975: 150), Wasser (1980: 246), Candusso & Lanzoni (1990: 308–311), Vellinga (2001: 140–141).

HABITAT: Solitary or in small groups, saprotrophic on soils, often in parks, also in coniferous forests.

GENERAL DISTRIBUTION: Africa: Algeria, Ghana, Morocco, Zaire; Asia: Azerbaijan, China, Iran, Israel; Europe: British Isles, Czech Republic, Denmark, France, Germany, Italy, Poland, Serbia, the Netherlands, Ukraine; South America: Venezuela.

MATERIAL EXAMINED: SP: Tel Aviv, Hayarqon Park, on lawn, 17.10.1972, leg. & det. N. Binyamini, rev. M. Didukh & S.P. Wasser (TELA-N. 72.220); Iron Wood, under *Pinus*, 24.02.1973, leg. & det. N. Binyamini, rev. M. Didukh & S.P. Wasser (TELA-N. 73.167).

NOTES: *Lepiota lilacea* is a very rare species for Israel. Vellinga (2001) notes that it can be very variable, especially with respect to basidiocarp size and color. Dark variants may resemble *L. felina* (Pers.) P. Karst in annular structure and the discrete disc and pileus cuticle squamules, but the two species differ in pileipellis structure and spore size (Vellinga 2001).

Lepiota micropholis (Berk. & Broome) Sacc., Syll. fung. 5: 61. 1887. FIGURE 13

Descriptions and illustrations: (Binyamini 1975: 150), Saccardo (1887: 61), Pegler (1972: 160, fig. 1/4 a–d).

HABITAT: Solitary or in small groups, saprotrophic on soil, often in parks, also in broadleaf forests.

GENERAL DISTRIBUTION: Africa: Kenya, Morocco; Asia: Japan, India, Israel, South Korea, Sri Lanka; Europe: Hungary, Ukraine; South America: Brazil, Venezuela.

MATERIAL EXAMINED: SP: Ramat Hasharon, in orchard near orange tree, 07.12.1974, leg. & det. N. Binyamini, rev. S.P. Wasser & M. Didukh (TELA-N. 74.457); Ramat-Gan, in *Eucalyptus* groves, 24.01.1978, leg. & det. N. Binyamini, rev. S.P. Wasser & M. Didukh (TELA-N. 79.270).

NOTES: *Lepiota micropholis* is a rare species for Israeli mycobiota, previously known from only two Israeli reports.

Acknowledgments

We thank the Dean of Graduate Studies Authority of Haifa University, Professor Sophia Menache, for supporting our research and this publication. Also, we thank Dr. I. Zmitrovich (Russia), Dr. E. Vellinga (USA), Dr. P. Volz (USA), Dr. S. Pennycook (New Zealand), and Dr. L. Norvell (USA) for critical reviews of the manuscript.

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MYCOTAXON

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Studies in lichens and lichenicolous fungi: notes on some taxa from North America

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Abstract — *Acarospora instrata* is placed in synonymy with *A. obpallens. Cyphelium brachysporum* is removed from synonymy with *C. notarisii* and considered endemic to the chaparral belt of southern California, USA. *Amandinea insperata, Cercidospora cladoniicola, Chaenothecopsis kalbii,* and *Usnea diffracta* are reported for the first time from North America.

Key words — Appalachian Mountains, coastal plain, fire frequency, New Mexico, tropical disjuncts

1. ***Acarospora obpallens*** (Nyl. ex Hasse) Zahlbr., Beihefte. Bot. Centralbl., 13: 161. 1902.

Syn. nov. *Acarospora instrata* H. Magn., Kongl. Svenska Vetensk. Handl., ser. 3, 7(4): 279. 1929. TYPE: U.S.A., New Mexico, C.J. Harnk s.n. (W!, holotype).

Recently, the holotype of *Acarospora instrata* was examined in the context of continuing revisionary work on *Acarospora* in North America. The holotype is a typical faveolate, epruinose specimen of *A. obpallens* on silicate-rich rock which is common in southern California and the mountains of the Sonoran Desert in Arizona (Knudsen 2008). The synonymy is made here. *Acarospora obpallens* is now documented from the New Mexican lichen biota. For descriptions and pictures of *A. obpallens* see Knudsen (2008) and Knudsen et al. (2008).

2. ***Amandinea insperata*** (Nyl.) H. Mayrhofer & Ropin, in Mayrhofer et al., Muelleria, 12: 190. 2000 ("1999").

During routine fieldwork in Nantahala National Forest in the southern Appalachian Mountains of eastern North America, the first author collected an odd *Amandinea* that did not seem to represent any species presently reported from the region. In light of the recent discovery of *Buellia japonica* (Tuck.) Tuck., a sub-tropical species, in a rich cove forest in adjacent Gorges State Park (Sheard et al. 2008) a search of the additional tropical species treated by Marbach (2000) was made. The material perfectly fits the description of *Amandinea insperata*, a species with a pan-tropical distribution similar to that of *B. japonica*. The species is presently known from South America (Argentina, Brazil, Ecuador, Columbia, Paraguay, and Uruguay), Central America (Guatemala), Africa (Kenya, Macronesia), and Australia. The species is similar to *B. japonica* in that it is most likely to be confused with a species of *Rinodina* because of its ascospores with elongated angular lumina (i.e. not *Buellia*-type). The brown hypothecium, black-capped paraphyses, and filiform conidia clearly distinguish the species from any *Rinodina* species in the region. This is the first report of the species from North America.

Specimen examined. – **U.S.A. NORTH CAROLINA. JACKSON CO.:** Nantahala National Forest, Chattooga Wild and Scenic River / Ellicott Rock Wilderness, above Fowler Creek, just S of Bull Pen Road, ~4.5 mi SE of Highlands, elev. 3000 ft., overgrown homestead site along stream with black locust (*Robinia pseudoacacia*), apple (*Malus*), and alder (*Alnus*) and large gneiss boulders, on branches of black locust, 18.ix.2006, J.C. Lendemer et al. 7891 (NY).

3. ***Cercidospora cladoniicola*** Alstrup, Graphis Scripta 8: 26. 1997. TYPE: Norway, Nord-Trøndelag, Flatanger, Røythaugfjellet, UTM 32W NS 8548-49, map 1623 I, alt. 40-120 m, ravine with vertical rock and coastal deciduous forest, on *Cladonia arbuscula*, 27.vii.1993, V. Alstrup (C, holotype).

In the material collected by the second and third authors during a field study of Santa Rosa Island in southern California in July 2007, we found the lichenicolous fungus *Cercidospora cladoniicola* totally bleaching the host squamules of *Cladonia pyxidata* (L.) Hoffm. The fungus is a parasite causing severe damage to the host thalli including deformation of the podetia. It is known from various *Cladonia* species, mostly *Cladonia* sect. *Cladina* such as *C. arbuscula* (Wallr.) Flot., *C. mitis* Sandst., and *C. portentosa* (Dufour) Coem., but it has also been reported on *C. pocillum* (Ach.) O.J. Rich. and *C. symphycarpia* (Flörke) Fr.

It is a widely distributed but rare species in the Northern Hemisphere, previously reported from Norway (Alstrup 1997, type locality), Denmark (Alstrup & Svane 1998), British Isles (Coppins 1998), Russia (Zhurbenko 2004) and Svalbard (Zhurbenko & Alstrup 2004). We report it new to North America.

In the genus, *Cercidospora cladoniicola* belongs to the group of species with 8-spored asci and 3-septate ascospores together with *C. lecidomae* Zhurb. & Triebel and *C. thamnoliicola* Ihlen (Ihlen & Wedin 2007). *Cercidospora cladoniicola* differs from both species in having ascospores brownish when mature and in its host. Moreover, from *C. lecidomae, C. cladoniicola* differs in having brown peridium versus emerald to glaucous green peridium and in having regularly 3-septate instead of 1–3 septate ascospores, which are not narrow to attenuated in lower part (Zhurbenko & Triebel 2003), and from *C. thamnoliicola* in larger ascospores (13–)16–18–20(–21) × (3–)4–4.5–5µm versus 11–14(–16) × 4–6µm (Zhurbenko & Alstrup 2004). Other 3-septate *Cercidospora* species, *C. soror* Obermayer & Triebel (Hafellner & Obermayer 1995) and *C. stereocaulorum* (Arnold) Hafellner (Hafellner 1987), have 4–spored asci.

Specimen examined. – **U.S.A. CALIFORNIA. SANTA BARBARA CO.:** Channel Islands, north slope of Black Mountain, first canyon west of truck trail, alt. 267 m., 33°58'58"N 120°4'4"W, senescent Bishop pine woods and chaparral, on *Cladonia pyxidata* on soil, 18.vii.2007, J. Kocourková & K. Knudsen s.n. (PRM 909679).

4. ***Chaenothecopsis kalbii*** Tibell & K. Ryman, Nova Hedwigia, 60: 206. 1995. TYPE: Brazil, Mato Grosso do Sul, 50 km SW of Campo Grande, 1979, *K. Kalb s.n.* (hb. Kalb, holotype).

Chaenothecopsis kalbii is a lichenicolous fungus occurring on the thallus of *Lecanora caesiorubella* Ach. (Tibell 1996). The species was originally described from Brazil, and is also known from Baja California Sur, Mexico and tropical Australia (Tibell 1996). The discovery of this species in the coastal plain of the southeastern United States is not unexpected, particularly in light of the number of species with similar sub-tropical or pan-tropical distributions that have been recently reported from that region (Beeching 2007, Lendemer 2008, Lendemer & Knudsen 2008, Lendemer & Lumbsch in press, Lendemer & Yahr 2004). Because of its short, black ascomata with a pale stalk, 1-septate ascospores (9–11 × 4–5.5 µm), and its lichenicolous habit (on otherwise pale thalli of *Lecanora caesiorubella*) *C. kalbii* is a distinctive species easily recognized in the field. Most likely, searching more host thalli will lead to the discovery of additional populations in North America.

Specimen examined. – **U.S.A. NORTH CAROLINA. CARTERET CO.:** Cape Lookout National Seashore, Shackleford Banks, maritime forest, on thallus of *Lecanora caesiorubella*, 19.iii.2003, R.C. Harris 47195 (NY).

5. ***Cyphelium brachysporum*** Nádv., Ann. Myc., 40: 133. 1942. TYPE: U.S.A., California, Riverside Co., near Murietta, 1903, H.E. Hasse s.n. (PRM!, holotype; BRA isotype).

In 1903 Herman Hasse collected a yellow *Cyphelium* on the wood of a dead shrub in southern California in western Riverside County near Murrieta. Based on the concepts of the period, he identified the specimen as *Cyphelium tigillare* (Ach.) Ach. In 1905 he returned to western Riverside County and according to labels collected in Murrieta more specimens of this *Cyphelium* on the dead wood of the common chaparral shrub *Adenostoma fasciculatum* Hook. & Arn.

In his flora he reported it as occurring "on dead shrubs near Murrieta" (Hasse 1913). In this general area in the Temecula Valley and in the surrounding foothills, chaparral containing *Adenostoma fasciculatum* occurs at elevations from approximately 300 to 700 meters.

One of Hasse's 1903 Murrieta collections ended up in a private herbarium in Czechoslovakia. During World War II, the lichenologist Nádvorník (1942) saw this specimen and realized it was new to science based on the small size of its one-septate ascospores and described it as *Cyphelium brachysporum*.

Studying a single isotype of the 1903 collection, Tibell synonymized *Cyphelium brachysporum* with *C. notarisii* (Tul.) Blomb. & Forssell (Tibell et al. 2003). He based this synonymy on the speculation that the ascospores of *C. brachysporum* described by Nádvorník were immature, and that if they were mature that would fall within the range of the ascospores of *C. notarisii* (which are submuriform/muriform).

Based on our study of the holotype, three later collections from 1905 by Hasse, and one modern collection we reject the synonymy of *Cyphelium brachysporum* with *C. notarisii. Cyphelium notarisii* is a well delineated taxon, easily recognized by its large, smooth, muriform ascospores (17–24 × 13–18 µm). The protologue of *C. brachysporum* reports 1-septate ascospores (11-13 x 8.5-10 µm). Our study of five specimens, including the holotype, revealed broadly ellipsoid ascospores ([13.5] –14.1– [14.7] × [10.0] –10.6-[11.3]µm; n=40, average +/– 1.96SE) overall slightly larger than the measurements given in the protologue, but still outside of the range of *C. notarisii*, and with a rare additional longitudinal division in the upper cell creating a sub-muriform ascospore. The ascospores of *C. brachysporum* are also minutely punctate and not constricted at the septum and the thallus contains rhizocarpic acid. The infrequent formation of an additional longitudinal septum in the upper cell of the ascospores led Tibell to assume they were immature muriform ascospores. While we observed this character in one collection from 1905 (NY), this was neither observed in the holotype nor the two additional collections from 1905 (FH) or the modern collection. It is our opinion that the mature ascospores in *C. brachysporum* are 1-septate, only occasionally becoming submuriform. The few submuriform ascospores we observed in the specimen at NY were still smaller in size than those of *C. notarisii*. Further, we are unaware of any collections of *C. notarisii* from southern California other than those we here refer to *C. brachysporum*. Otherwise, *C. brachysporum* is similar in appearance to *C. tigillare* with apothecia immersed in thalline warts, the exciple thin throughout, rather than sessile like *C. pinicola* Tibell with the exciple strongly thickened at the base.

The rarity of *Cyphelium brachysporum* is explained by its occurrence on the unburned wood of dead chaparral shrubs at low elevations. For instance, before widespread urbanization and urban sprawl in southern California, old-growth chaparral was common. In old-growth chaparral the shrubs at ages of thirty-to-sixty years become senescent and die. It is on the wood of these dead shrubs that *C. brachysporum* was first collected. In the last hundred years anthropogenic fires have become common in the southern California chaparral with fire frequencies as low as every twenty years. Old-growth chaparral is now rare (Knudsen 2006). The single modern collection of *C. brachysporum* was made in old-growth chaparral in San Luis Obispo County in Los Osos on the dead wood of Morro Manzanita, *Arctostaphylos morroensis* Wiesl. & B. Schreib. This is a unique chaparral type, Morro Bay chaparral, restricted to the local sand dunes below 200 meters, that has very low natural fire frequency. This dune chaparral also supports the only known populations of *Sulcaria isidiifera* Brodo.

ADDITIONAL SPECIMENS EXAMINED. – **U.S.A. CALIFORNIA. RIVERSIDE CO.:** Murietta, 1905, H.E. Hasse s.n. (FH [2 specimens], NY); **SAN LUIS OBISPO CO.:** Los Osos, Los Osos Oaks State Reserve, 57 m, 16.xii. 2005, Knudsen et. al 4615 (UCR).

6. ***Leptogium juressianum*** Tav., Portug. Acta Biol. Ser. B, 3(1–2): 68. 1950.

Recently, while determining specimens from the southern Appalachian Mountains collected by Sean Beeching the first author encountered an unusual isidiate *Leptogium* specimen with an arachnoid tomentum on both the upper and lower surfaces of the thallus. As this type of tomentum is unusual in the genus *Leptogium* and it rarely occurs on the upper surface of the thallus as well as the lower surface, a search of the relevant literature (Jørgensen & James 1983) quickly led to the name *L. juressianum*. Since according to Jørgensen and James (1983) *L. juressianum* is a rare species known only from hyperoceanic areas of Europe (Portugal and Ireland) a duplicate was sent to P.M. Jørgensen who kindly confirmed the identification. *Leptogium juressianum* is thus here reported for the first time form North America.

A subsequent visit by the first author, Sean Beeching, and Malcolm Hodges to the locality where *L. juressianum* was found yielded no further material of the species. The locality where *L. juressianum* was found is a middle-elevation serpentine barren, a habitat that is rare in the southern Appalachian Mountains and has previously yielded other rare and endemic species (see Lendemer 2007 for a discussion).

SPECIMEN EXAMINED. – **U.S.A. NORTH CAROLINA. CLAY CO.:** Nantahala National Forest, vicinity of Buck Creek Barrens, 2006, S.Q. Beeching s.n. (NY).

7. ***Usnea diffracta*** Vain., Bot. Mag. Tokyo, 35: 45. 1921. TYPE: Japan, Hokkaido, Prov. Kushiro, on *Betula*, 19.viii.1918, A. Yasuda 231 (TUR, holotype).

While organizing the oversized specimens of lichens in the herbarium of the Academy of Natural Sciences of Philadelphia (PH), the first author came across an old folder of *Usnea* specimens that had apparently not been seen by any other lichenologists as the specimens bore no annotations by A.C.T.W. Herre or J. Motyka who annotated many other *Usnea* specimens at PH. The first specimen in the folder was unidentified, however was immediately recognizable as the pendant Eurasian arctic-boreal taxon *Usnea diffracta* which is widely distributed in northwestern Asia (Japan, Korea, Siberia, Sakhalin Island, and Taiwan (fide Motyka 1936–38)). Interestingly, the specimen had been collected in Sitka, Alaska in 1898.

Sitka is a city on Baranof Island in the Alexander Archipelago in southeastern Alaska, USA. The occurrence of *Usnea diffracta* in North America, especially Alaska, is not unexpected considering the circumpolar nature of other *Usnea* taxa such as *U. filipendula* Stirt. and *U. longissima* Ach. It is remarkable that such a distinctive and conspicuous species has not been previously been reported from North America (Esslinger 2008). The apparent lack of previous records of *U. diffracta* in North America could simply be an indication of how under-collected the continent is as a whole. While this explanation is a logical one for the inconspicuous crustose taxa, cryptic taxa, and lichenicolous fungi reported elsewhere in this paper it is unlikely that such a conspicuous lichen would have gone uncollected and unrecognized. Perhaps *Usnea diffracta* is a rare species at the edge of its range in North America. Considering that the collection reported here was made more than a century ago, in 1898, and no further collections appear to have been mentioned in the literature, this is likely the case. Hopefully this note will stimulate others to check their *Usnea* collections for *U. diffracta*, and maybe additional collections, hopefully modern, will be found. The lax pendant thallus, presence of annular pseudocyphellae on the branches, and presence of diffractaic acid (CK+ yellow-gold, C-, K-) in the medulla are diagnostic for *U. diffracta*. Descriptions and illustrations of *U. diffracta* have been provided by Asahina (1956) and Ohmura (2001).

SPECIMEN EXAMINED. – **U.S.A. ALASKA:** Sitka, viii.1898, S.L. Schumo s.n. (PH).

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Boletellus piakaii sp. nov. and a new distribution record for *Boletellus ananas* var. *ananas* from Guyana

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Abstract — *Boletellus piakaii* (*Boletaceae, Boletales, Basidiomycota*) is described as new to science. *Boletellus ananas* var. *ananas* is recorded for the first time from the Guiana Shield region. These boletes were collected from tropical forests dominated by ectomycorrhizal *Dicymbe* spp. (*Caesalpiniaceae*) in the Pakaraima Mountains of western Guyana. A key is provided for *Boletellus* species known to occur in Guyana.

Key words — bolete, monodominant forest, tropical fungi, taxonomy

Introduction

The genus *Boletellus* Murrill (*Boletaceae, Boletales, Basidiomycota*) encompasses ~ 46 described species worldwide, the majority with tropical distributions (Heinemann & Goossens-Fontana 1954, Snell & Dick 1970, Smith & Thiers 1971, Corner 1972, Horak 1977, Singer 1986 Singer et al. 1992, Watling 2001, Halling & Mueller 2005, Ortiz-Santana et al. 2007, Fulgenzi et al. 2008). For a discussion on various authors' concepts of *Boletellus* see Fulgenzi et al. (2008).

Here we describe *Boletellus piakaii* sp. nov. and provide a new distribution record, host association, and redescription for *Boletellus ananas* var. *ananas* occurring in ectomycorrhizal (EM) *Dicymbe* (*Caesalpiniaceae*) forests of Guyana. The new species is easily accommodated in *Boletellus* based on its olivaceous brown, longitudinally ridged basidiospores, dry pileus, tubulose, blue-staining hymenophore, and lack of clamp connections. Previous work in Guyana within

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this genus has lead to the description of two new species, *Boletellus exiguus* T.W. Henkel & Fulgenzi and *Boletellus dicymbophilus* Fulgenzi & T.W. Henkel (Fulgenzi et al. 2008). A key is provided for *Boletellus* taxa known to occur in Guyana.

Materials and methods

Collecting expeditions were conducted during the May–July rainy seasons of 1997–99 in the Upper Ireng River Basin along Guyana's western border with Brazil in the west-central Pakaraima Mountains, and of 2000–07 in the Upper Potaro River Basin ~ 30 km north of the Ireng River site. At each site fungi were collected within a five km radius of a previously established base camp in forests dominated by *Dicymbe corymbosa* Spruce ex Benth. (Henkel et al. 2002, Henkel 2003).

Basidiomata were examined in the field for their fresh characteristics. Color was subjectively described and recorded according to Kornerup & Wanscher (1978) with color plates noted in parentheses (e.g., 3C4). Macro-chemical spot tests were performed following Singer (1986). Basidiomata were field-dried with silica gel beads.

Microscopic anatomical details were determined on fresh specimens at the base camp with an EPOI microscope and in the laboratory using an Olympus BX51 microscope with bright field and phase contrast optics. Fungal tissue of dried specimens was rehydrated and mounted in either H_20, 3% KOH, or Melzer's solution. For each taxon a minimum of 20 basidiospores, basidia, cystidia and other structures were measured. Line drawings were made with a phototube, inked and scanned. Scanning electron micrographs of spores were obtained with either a Jeol JSM-6400 or Topcon ABT32 scanning electron microscope. Specimens are deposited in the following herbaria as noted: BRG, HSU, and NY (Holmgren et al. 1990).

Taxonomic descriptions

Boletellus piakaii T.W. Henkel & Fulgenzi, **sp. nov.** FIGS 1–2

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> *Pileus olivaceo-brunneus, rugosus et minute granulatus, 40–72 mm late; trama caerulescens ubi exposita. Stipes stramineus, apice cum collo porphyreo, longitudinaliter porcatus, 98–120 × 7–9 mm. Basidiosporae olivaceo-brunneae in massa, amygdaliformes, longitudinaliter porcatae, 9.8–12.4 × 5–7.4 µm.*
>
> HOLOTYPE: Henkel 8728 (BRG; ISOTYPE: HSU, NY)
>
> ETYMOLOGY. The species epithet recognizes the collector of the holotype, Piakai Henkel.

KEY CHARACTERS — *Boletellus piakaii* is recognized in the field by its olive-brown rugose pileus, yellow-tan subequal stipe with maroon longitudinal striations,

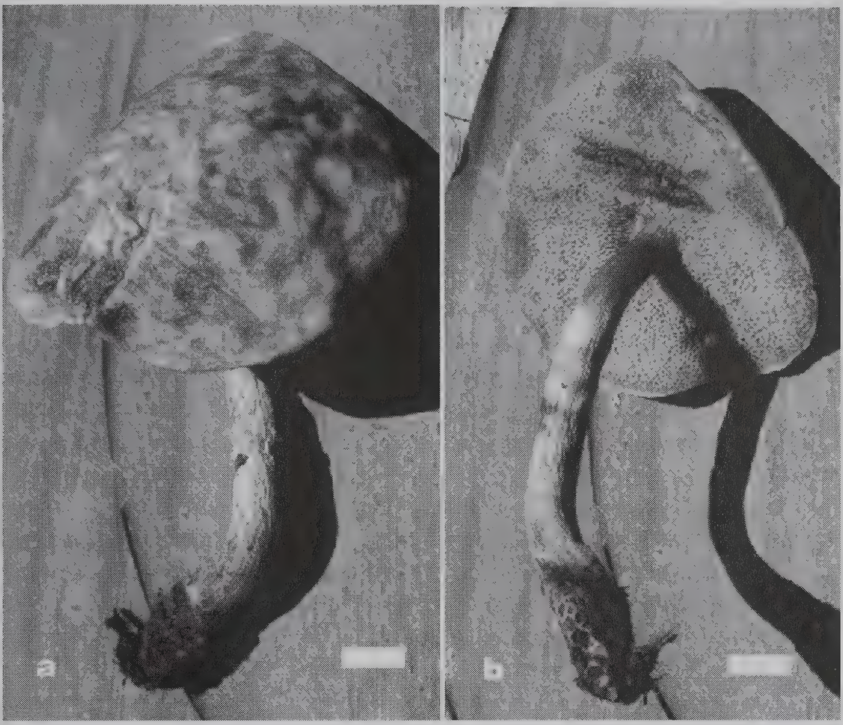

Fig. 1. Basidioma of *Boletellus piakaii* (BRG HOLOTYPE Henkel 8728).
a. Dorsal. b. Ventral. Bar = 10 mm.

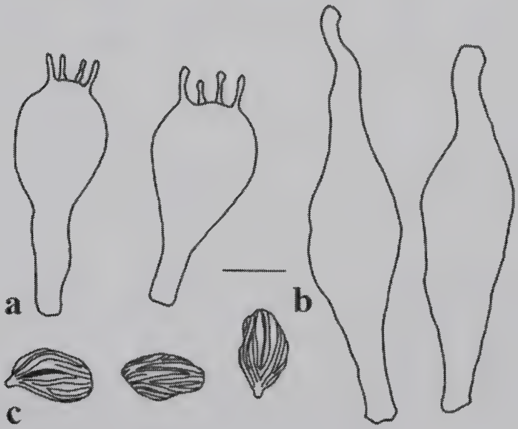

Fig. 2. Microscopic features of *Boletellus piakaii* (BRG HOLOTYPE Henkel 8728)
a. Basidia. b. Pleurocystidia. c. Basidiospores. Bar = 10 μm.

and a rapid bluing reaction of the bruised hymenophore and exposed trama. Microscopically *B. piakaii* is distinguished by having basidiospores that do not exceed 12.5 µm in length, basidia with long sterigmata and numerous golden refractive globules, a cystoderm pileipellis of irregularly globose to subangular cells, and numerous thick-walled hyphae in the pileus trama.

MACROCHARACTERS — PILEUS (25) 40–72 mm broad, convex to planoconvex, dark brown (6F8) throughout when young to olive brown (5E6–5E8–5F8) to olive-yellow (4A8–4B8–4C8–4D8) with age, rugulose to rugose, minutely granular (under 10× lens), moist, margin slightly inrolled and entire; TRAMA 1–2 mm thick at margin, 3–5 mm over tubes, 6–12 mm above stipe, off-white, immediately green-blue (26D5) upon exposure, fading to dingy-green (28D6) and yellowing after several minutes, solid; TUBES 3–6 mm long at margin, 8–13 mm centrally, 6–7 mm at stipe, of irregular lengths, narrowly and deeply depressed around stipe, with short decurrent teeth 1–2 mm long, light olive-yellow (3A7–3B7), quickly blue-green (20F8–24F8) upon exposure, eventually fading to dull brown; PORES yellow (2A8) when immature to olive-yellow (3A7–3B7–4B8–4C8), immediately blue-green (24F8) with pressure, then fading gradually to green (27F8), green-brown (4E6), and eventually brown (6E8–6F8), 1–1.5 per mm, subisodiametric to angular; STIPE (60) 98–120 × 7–13 mm, subequal, enlarging gradually to 11–13 mm broad at base, ground tissue yellow-tan (4A5–4B5–4C8), overlaid with pinkish brown (6D5–6E5–6D4–6E4) to red-maroon (7E6–7E7–7D8–8E7) longitudinal striations throughout, these darkening with age and handling, apex with light red-brown (7A5) band, lower 20–25 mm with densely matted dark-brown (7F4–8F2) tomentum; SUBTENDING HYPHAE con-colorous and often associated with ectomycorrhizal rootlets; TRAMA off-white to yellow (4A7–4B7) to brown (7D5–7E5–7D8–8E7) with age, transiently bluing upon exposure, solid; ODOR minimal, pleasant; TASTE mild.

MICROCHARACTERS — BASIDIOSPORES dark olive-brown (4F8–5F8) in medium to heavy deposit, 9.8–12.4 × 5–7.4 µm (mean Q = 1.69), golden-olive in H_2O and KOH, inamyloid, amygdaliform, 1–2 guttulate, with 18–22 longitudinal ridges; ridges < 1 µm tall, repeatedly dichotomously forked, converging at both poles, transverse striae absent; hilar appendage 0.5–0.9 µm long; BASIDIA 32.4–46 × 13.1–15.6 µm, clavate, wall hyaline in H_2O and KOH, with numerous refractive globules, these light golden in H_2O, lighter in KOH, 4-sterigmate; STERIGMATA 3.2–5 µm long; PLEUROCYSTIDIA 37–69 × 8.4–12.4 µm, ventricose-rostrate, frequent, arising from the subhymenium, projecting 21–30.8 µm beyond the hymenial palisade, hyaline, thin-walled; CHEILOCYSTIDIA absent; HYMENOPHORAL TRAMA boletoid, strongly divergent; MEDIOSTRATUM 19.7–49.4 µm wide, of many thin-walled, nearly parallel hyphae, golden in H_2O, lighter and gelatinized in KOH; LATERAL STRATUM hyphae 7.4–12.4 µm wide, hyaline, nongelatinized; PILEIPELLIS a cystoderm of irregularly globose to subangular cells; these thin-walled, faint-golden in H_2O, hyaline in KOH; PILEUS TRAMA of interwoven hyphae, many with thickened walls; individual hyphae 4.4–11.1 µm wide, wall up to 0.5 µm thick, regularly septate, devoid of contents, in mass light golden in H_2O, lighter in KOH; STIPITIPELLIS an interwoven trichodermial palisade of cylindrical elements with inflated terminal cells, in mass golden orange in H_2O, lighter in KOH; TERMINAL CELLS projecting 22.5–40 µm, cylindrical to clavate, occasionally ventricose to mucronate, these concentrated on longitudinal striations; SUBPELLIS hyphae interspersed with external burgundy acerose crystals; STIPE TRAMA of densely packed parallel hyphae, in mass faint golden in H_2O, lighter in KOH; individual hyphae 4–9.6 µm wide, hyaline in H_2O and KOH, regularly septate; CLAMP CONNECTIONS absent.

MACROCHEMICAL REACTIONS — NH_4OH rapidly light red-brown (8D6) on pileus, soon darkening, burgundy (9E8) on stipe ground, black on longitudinal striations, light burgundy (9D6) on stipe trama; KOH light orange-brown (7C6) to burgundy (8F7) on pileus, burgundy (8F7) on stipe, red-brown (8D8) on pileus and stipe trama; $FeSO_4$ dark grey-green (28F4) on pileus, dark green (29F5) on tube mouths, dark green (28F8) on stipe, yellow-green (29D6) on stipe trama.

ECOLOGY, RANGE, DISTRIBUTION — Solitary to scattered on root mat in *D. corymbosa* forest, rarely on lower base of *D. corymbosa* trunks; more frequent late in the rainy season; known only from the type locality in the Upper Potaro River Basin of Guyana.

REPRESENTATIVE SPECIMENS EXAMINED. **GUYANA.** REGION 8: POTARO-SIPARUNI. Pakaraima Mountains, Upper Potaro River, within a 5 km radius of 'Potaro Base Camp' (5° 18′ 04.8″ N, 59° 54′ 40.4″ W, elevation 710–750 m); vicinity of Potaro base camp, 2 May 2001, *Henkel 8013* (BRG; HSU); in *Dicymbe* plot 1, 9 May 2001, *Henkel 8077* (BRG; HSU), 2 July 2004, *Henkel 8728* (HOLOTYPE, BRG; ISOTYPE: HSU, NY); 1 km west of Potaro base camp, 30 May 2005, *Henkel 8810* (BRG; HSU); 1.5 km southeast of Potaro base camp on 'Benny's ridge', 14 August 2007, *Henkel* 8869 (BRG; HSU); in *Dicymbe* plot 2, 24 August 2007, *Henkel* 8878 (BRG; HSU); 0.75 km northeast of Potaro base camp between north end of 'Benny's ridge' and 'Leon camp', 25 August 2007, *Henkel* 8882 (BRG; HSU).

COMMENTS — Within the genus *B. piakaii* is best disposed in Section *Chrysenteroidei* Singer due to the longitudinally ridged basidiospores, dry pileus lacking in red tints, and the absence of a veil (Snell & Dick 1970, Singer 1986). *Boletellus piakaii* is similar in stature and shares the brown, rugose pileus reported for *Boletellus longicollis* (Ces.) Pegler & T.W.K. Young from Malaysia and Japan; *B. longicollis* can be distinguished by its white, gelatinous, appendiculate veil and non-cyanescent trama (Corner 1972, Imazeki et al. 1988). Among other Malaysian boletelli only *Boletellus fallax* (Corner) Watling non Singer has cyanescent trama and lacks an appendiculate veil; *B. fallax* otherwise differs from *B. piakaii* in having longer basidiospores (18–24 µm vs. 9.8–12.4 µm), longer pleurocystidia (60–140 µm vs. 37–69 µm), a smaller stature (pileus diam 25–45 mm vs. (25) 40–72 mm, stipe length 22–70 mm vs. (60) 98–120 mm), and red tints in the pileus (Corner 1972). Among Congolian *Boletellus* species none are similar to *B. piakaii*; only *Boletellus longipes* Heinem. has a similar stature, but larger basidiospores (12.7–16.2 × 7.2–8.5 µm vs. 9.8–12.4 × 5–7.4 µm), an orange stipe, and areolate pileus (Heinemann & Goossens-Fontana 1954). The Central American *Boletellus belizensis* B. Ortiz & T.J. Baroni and *Boletellus domingensis* B. Ortiz & Lodge lack marginal appendiculae and have a cyanescent reaction in the exposed pileus trama and bruised hymenophore, yet these species are dissimilar to *B. piakaii* in having smaller statures (pileus diam 24–40 and 18–60 mm vs. (25) 40–72 mm, stipe length 60–70 and 27–55 mm vs. (60) 98–120 mm), larger basidiospores (12–14.4 × 5.6–7.2 and 12.8–16 × 5.6–8 µm vs. 9.8–12.4 × 5–7.4 µm) pruinose stipe ornamentations, and in lacking a rugulose to rugose pileus surface (Ortiz-Santana et al. 2007).

Boletellus ananas (M.A. Curtis) Murrill, Mycologia 1:10. 1909 var. ***ananas***

Figs 3–5

≡ *Boletus ananas* M.A. Curtis Amer. J. Sci. Arts 6 : 351. 1848.
= *Boletus coccineus* Fr. Epic. Myc. 423. 1838, nom. illegit., non Bull. 1791.
≡ *Strobilomyces coccineus* Sacc., Syll. Fungorum 6: 50 1888 ut "Fr".
≡ *Boletellus coccineus* (Sacc.) Singer in Singer et al. Beih. Nova Hedwigia 105: 6: 1992 ut "(Fr.)".
= *Boletus isabellinus* Peck, Bull. Torrey Bot. Club 24: 146. 1897, nom. illegit., non Schwein. 1822.
= *Strobilomyces pallescens* Cooke & Massee in Cooke, Grevillea 18: 5 1889.
≡ *Boletellus pallescens* (Cooke & Massee) E.-J. Gilbert, Bolets. 107. 1931.

Key characters — *Boletellus ananas* var. *ananas* is recorded for the first time from northeastern South America. This striking bolete is recognized in the field by its red-pink squamose pileus, membranous marginal appendiculae, bright yellow, rapidly blue-staining hymenophore, cyanescent trama, and tree trunk fruiting habit. These features are consistent with those of *B. ananas* var. *ananas* as described from other regions (McNabb 1967, Smith & Thiers 1971, Corner 1972, Singer 1986, Halling & Mueller 2005). Microscopically *B. ananas* var. *ananas* is distinguished by large basidiospores with cross striae on the ridges and spirally encrusted hyphae in the marginal appendiculae and stipe trama.

Macrocharacters — pileus 33–74 mm wide, convex to planoconvex, with appressed to recurved squamules, red-brown (10B7–10D7) to red-tan (7D5–8D4–8E5) to pink (9A4–10B4) to pink-grey (10C4), vestiture concentrated and more squarrose on disk, extending out of cream (1A2–3A2–3A3–4A3) to light orange-pink (7A3) to light pink-red (9A6) floccose ground; margin

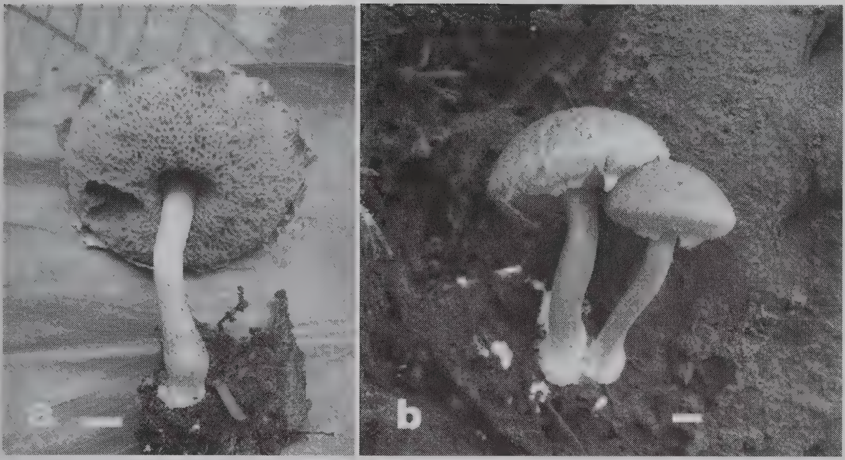

Fig. 3. Basidiomata of *Boletellus ananas* var. *ananas*.
a. HSU Henkel 8819. b. Fruiting habit on humic deposit of *Dicymbe* trunk, Upper Potaro Basin, Guyana. Bar = 10 mm.

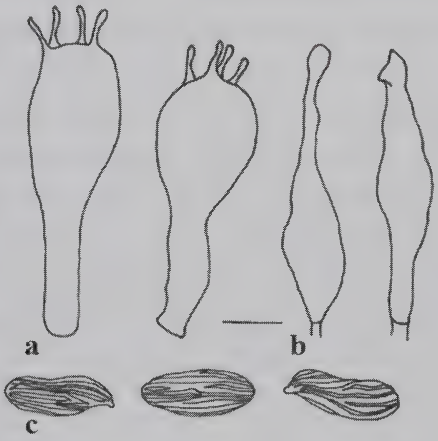

Fig. 4. Microscopic features of *Boletellus ananas* var. *ananas* (HSU Henkel 8168)
a. Basidia. b. Pleurocystidia. c. Basidiospores. Bar = 10 μm.

entire and clasping stipe when young, at maturity separating into triangular appendiculae, these 6–12 × 3–10 mm, buff white (5A3–5B4), occasionally faint pink; moist; trama 2–3 mm thick at margin, 7–10 mm over tubes, 11–18 mm centrally, buff white to light yellow (3A3), rapidly bluing (23C7) upon exposure, solid; TUBES 1–5 mm long at margin, 10–20 mm centrally, 4–6 mm at stipe, broadly and deeply depressed around stipe, of irregular lengths, bright yellow

(3A8) to olive yellow (2B7–3B7–3C7) to mustard yellow (4A8–4B8), rapidly bluing (23C7) upon exposure; PORES concolorous with tubes, rapidly blue-green (23C8) with pressure, 0.5–1.5 per mm, angular; STIPE 53–115 × 6–14 mm broad, subequal, gradually enlarging toward base to 10–19 mm, apical portion cream (3A4) to pink (9A4), middle portion finely longitudinally striate, striations darkening with handling, red-lavender (11A6–11B4–11B7–11B8) to brown-red (9E8–10E8), lighter with age, immediately above basal tomentum cream (3A2–3A4) with few striations; BASAL TOMENTUM of white strigose hairs over lower 6–50 mm, occasionally subtended by ectomycorrhizal rootlets; TRAMA white to buff-tan (5B4) to light yellow (3A4), slightly bluing with exposure; solid; ODOR non-descript; TASTE mild.

MICROCHARACTERS — BASIDIOSPORES olivaceous-brown (4D7-4E7-5E6–5F6) in medium to heavy deposit, 17.5–22.2 × 6.4–8 µm (mean Q = 2.73), golden in H_2O and KOH, inamyloid, amygdaliform, one to multiguttulate; wall 0.5–1 µm thick, with 12–14 longitudinal ridges; ridges < 1 µm tall, occasionally bifurcating, converging at poles, with minute cross-striae; hilar appendage 0.3–1 µm long; BASIDIA 39–57 × 11–15 µm, clavate, wall hyaline in H_2O and KOH, with numerous refractive globules, these faint golden in H_2O and KOH, 4-sterigmate; PLEUROCYSTIDIA 42–47 × 8–12 µm, ventricose-rostrate, slightly capitate, frequent, arising from the sub-hymenium, projecting 19.3–29.6 µm above the hymenial palisade, thin-walled, hyaline, devoid of refractive contents; CHEILOCYSTIDIA 19–42 (51) × 5–11 µm, ventricose, cylindrical, to narrowly clavate, thin-walled, infrequent; HYMENOPHORAL TRAMA boletoid, strongly divergent; medio-stratum 24.7–45.7 µm wide, of many parallel, slightly interwoven hyphae, faintly grey-yellow in H_2O, lighter and gelatinized in KOH; lateral stratum hyphae 4.4–8.4 µm wide, hyaline and gelatinized in KOH, regularly septate; PILEIPELLIS a densely interwoven trichodermial palisade of cylindrical elements with inflated terminal cells, in mass faint golden in H_2O, lighter in KOH; terminal cells 23.5–51.9 × 9.4–16.8 µm, hyaline in H_2O and KOH, inamyloid, cylindrical to clavate, interwoven, concentrated on squamules; *marginal appendiculae* composed of wefts of interwoven inflated hyphae, some with faint golden spirally arranged encrusting pigments evident in H_2O, KOH, and Melzer's; PILEUS TRAMA highly interwoven; individual hyphae 7.4–11.1 µm wide, hyaline in H_2O, gelatinized and hyaline in KOH, regularly septate; STIPITIPELLIS a trichodermial palisade of cylindrical elements with inflated terminal cells, in mass golden in H_2O, lighter in KOH; terminal cells projecting 30.4–63 µm, cylindrical to clavate, occasionally mucronate; STIPE TRAMA densely interwoven, in mass golden in H_2O, lighter in KOH; individual hyphae 4.9–7.2 µm wide, hyaline in H_2O and KOH, with spirally arranged faint golden encrusting pigments, these evident in KOH, Meltzer's, and H_2O; CLAMP CONNECTIONS absent.

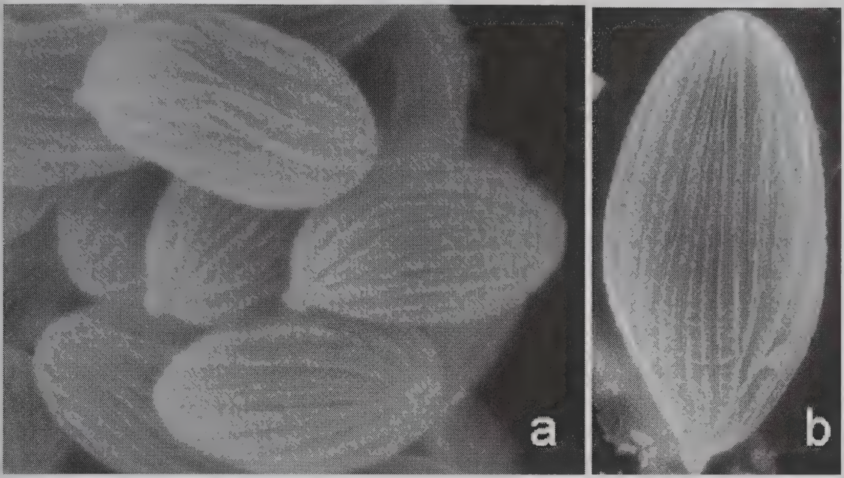

Fig. 5. Scanning electron micrographs of basidiospores of *Boletellus* species from Guyana.
a. *Boletellus piakaii* (HSU Henkel 8013) ×4000.
b. *Boletellus ananas* var. *ananas* (HSU Henkel 8168) ×6300.

MACROCHEMICAL REACTIONS — NH_4OH olivaceous yellow (4D6) on pileus, dirty yellow (4C7) on tube mouths, bright red (10B8) on stipe, tan (6C4) on basal tomentum, yellow on trama of pileus and stipe; KOH bleaching pileus ground, rusty-brown (7D8) on squamules, orange-brown (5C6) on stipe, orange-yellow on pileus trama, burgundy to orange on stipe trama; $FeSO_4$ pink to faint grey on pileus, steel-grey on stipe; olive-green (26F6) on tube edges.

ECOLOGY, RANGE, DISTRIBUTION — In Guyana typically fruiting singly or in pairs within 1–2 m above ground level on *D. corymbosa* trunks, associated with ectomycorrhizas within humic accumulations; rarely found fruiting on ground on heavily decayed, root-penetrated wood; recorded from the Upper Potaro and Upper Ireng River Basins in Guyana; also known from south-eastern North America, Central America, New Zealand, Malaysia, and possibly Australia (Corner 1972, Singer et al. 1983).

REPRESENTATIVE SPECIMENS EXAMINED — **BRAZIL, AMAZONAS**: *Boletellus ananas* var. *minor*, Estrada Manaus-Caracarai, 4 April 1980, *Singer B10913* (HOLOTYPE, INPA). **GUYANA, REGION 8, Potaro-Siparuni,** Pakaraima Mountains, Upper Ireng River Basin, west bank of Suruwabaru Creek, 1 km upstream from confluence with Yuarka creek, 2 March 1997, *Henkel 6263- 6264;* 23 May 1999, *Henkel 7038*; Upper Potaro River, within a 5 km radius of 'Potaro Base Camp' (5° 18′ 04.8″ N, 59° 54′ 40.4″ W, elevation 710–750 m); Ayanganna airstrip, 19 May 2000, *Henkel 7400*; vicinity of Potaro base camp, 30 June 2000, *Henkel 7925*; 4 km southwest of Potaro base camp near *Dicymbe* plot 3, 18 May 2001, *Henkel 8168*; vicinity of Potaro base camp, 25 July 2003, *Henkel 8614*, 5 July 2004, *Henkel 8734*, 31 May 2005, *Henkel 8819;* 2 km south of Potaro base camp, 2 June 2005, *Henkel 8826*; 0.75 km west of Potaro base camp, 3 June 2005, *Henkel 8833.* Guyana collections housed in BRG and HSU.

Commentary — We have not adopted the nomenclature erected by Singer et al. (1992: i.e. *Boletellus coccineus* var. *coccineus* for *Boletellus ananas* var. *ananas*). Singer created this name in the mistaken belief that the earliest available name for the taxon was *Boletus coccineus* Fr. 1838. However, Fries's name is an illegitimate later homonym (cf. *Boletus coccineus* Bull. 1791), and Singer's combination is actually based on *Strobilomyces coccineus* Sacc. 1888. The earliest available name for the taxon is therefore *Boletus ananas* M.A. Curtis 1848, the basionym of *Boletellus ananas*.

Boletellus ananas var. *ananas*, as the type of the genus, is in Section *Boletellus* Singer based on the squamose, dry pileus with red-pink tones, a marginal veil that clasps the stipe when immature, and longitudinally ridged spores that are > 16 µm long (Singer 1986). Most characters of the Guyana material other than host association are consistent with those previously reported for *B. ananas* var. *ananas*; one minor deviation is that the pleuro-cystidia of Guyana specimens are consistently shorter (< 50 µm) than those reported for collections from Malaysia (50–95 µm), and the Dominican Republic and Belize (44–91.2 µm) (Corner 1972, Ortiz-Santana et al. 2007), but consistent with those of material from southeastern North America, New Zealand, and Costa Rica (McNabb 1967, Smith & Thiers 1971, Singer et al. 1983). *Boletellus ananas* var. *ananas* has consistently larger basidiomata than *B. ananas* var. *minor* Singer from Brazil and Nicaragua, and lacks the thick-walled cheilocystidia of *B. ananas* var. *crassotunicatus* Singer from Nicaragua and Panama and laciniate-reticulate stipe ornamentation of *B. coccineus* var. *amarus* Singer from Honduras and Belize (Singer et al. 1983, Singer et al. 1992, Ortiz-Santana et al. 2007).

The habit of fruiting on tree trunks has been reported for varieties of *B. ananas* from southeastern North America, Costa Rica, Brazil, Panama, Nicaragua, and Guyana (Murrill 1909, Singer et al. 1983, this paper), although terrestrial fruiting has been reported in Malaysia (Corner 1972) and Central America (T. Baroni pers. comm.). Due to the typically elevated fruiting habit and occurrence on dead wood the ectomycorrhizal status of *B. ananas* has been debated, although all collections have been made in association with ectotrophic host trees including *Pinus* and *Quercus* spp. in southeastern North America (Murrill 1909) and Central America (Singer et al. 1983, Halling & Mueller 2005, Ortiz-Santana et al. 2007), *Quercus humboldtii* Bonpl. in Colombia (Franco-Molano & Uribe-Calle 2000), various *Fagaceae* and *Dipterocarpaceae* spp. in Malaysia (Corner 1972), and *Leptospermum* and *Pinus* spp. in New Zealand (McNabb 1967). In Guyana the humic deposits on *Dicymbe* trunks bearing *B. ananas* are consistently permeated with abundant ectomycorrhizas (Woolley et al. 2008).

Boletellus in Guyana

Key to *Boletellus* species

1a. Marginal veil present, becoming appendiculate; pileus squamose to squamulose, with pinkish tones .... ***B. ananas* var. *ananas***

1b. Marginal veil absent; pileus squamulose or otherwise, lacking pinkish tones 2

2a. Fruiting terrestrial, rarely on tree trunks; pileus ≥ 46 mm broad; stipe ≥ 98 mm long; basidiospores not exceeding 12.5 × 7 µm .... ***B. piakaii***

2b. Fruiting on tree trunks; pileus ≤ 45 mm broad; stipe ≤ 80 mm long; basidiospores up to 15 × 11 µm 3

3a. Basidiomata small; pileus 9–33 mm broad; stipe 7–34 × 1–4 mm; pleurocystidia infrequent, ventricose, 65–85 (100) × 14–20 µm ..... ***B. exiguus***

3b. Basidiomata larger; pileus 19–34 mm broad; stipe 41–60 (80) × 4–7 mm; pleurocystidia frequent, cylindrical to narrowly clavate, 33–56 × 7–12 µm .... ***B. dicymbophilus***

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New records of *Scleroderma* from Northeastern Brazil

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Abstract — Survey on species of *Scleroderma* in native trees from the Atlantic rain forest biome, and introduced cultures of *Pinus*, was performed in the States of Paraíba, Pernambuco and Rio Grande do Norte. *Scleroderma albidum*, *S. bovista*, *S. citrinum* and *S. nitidum* were identified, the first three being new records to the Northeast Brazil and the latter, to the country. Descriptions of macro and microscopic features and SEM-photos of the spore ornamentation of these species are given.

Key words — gasteromycetes, *Boletales*, taxonomy, biodiversity

Introduction

The genus *Scleroderma* includes 25 ectomycorrhizal taxa usually known as earth balls, distributed worldwide (Kirk et al. 2001). This genus of poisonous fungi with hard-skinned basidiomata is recognized by its epigeous and single-layered peridium opening by irregular dehiscence and gleba without capillitium.

To date, *Scleroderma albidum*, *S. areolatum* Ehrenb., *S. bougheri* Trappe, et al., *S. bovista*, *S. cepa* Pers., *S. citrinum*, *S. floridanum* Guzmán, *S. fuscum* (Corda) E. Fisch., *S. uruguayense* (Guzmán) Guzmán, *S. verrucosum* (Bull.) Pers., *S. vulgare* Hornem., *S. tenerum* Berk. & M.A. Curtis and *S. polyrhizum* (J.F. Gmel.) Pers. have been reported in Brazil by Rick (1961), Guzmán (1970), Bononi et al. (1981), Baseia & Milanez (2000) and Giachini et al. (2000). These species have been investigated for their anti-inflammatory and hemostatic properties (Guzmán 1970, Liu 1984). In nature, they are important ectomycorrhizal fungi and many species have been studied in light of their potential to enhance tree growth (Kropp & Trappe 1982, Molina & Trappe 1982, Danielson 1984, Garrido 1984, Jones et al. 1986, Richter & Bruhn 1989, 1990; Richter 1992). This paper reports the species of *Scleroderma* found in native forests from the Atlantic rainforest biome and in introduced cultures of *Pinus*, the main purpose being to increase the knowledge about this taxon.

Material and methods

Material was colleted during field trips to Atlantic rainforest of the States of Paraíba, Pernambuco and Rio Grande do Norte. The material was deposited in the Herbarium of the Universidad of Pernambuco, Brazil (URM), and in the Herbarium of the Universidade Federal do Rio Grande do Norte, Brazil (UFRN-fungos).

Hand-cut sections of dried material were mounted in Melzer's reagent, 5% KOH, water or cotton blue for microscopic examination (Guzmán 1970). For SEM pictures, the spores were air-dried, mounted on aluminum stubs, sputter coated (Bal-Tec SCD-050) with gold and examined in a Philips XL 20 scanning electron microscope. The mycorrhizal observations were performed using methods developed by Agerer (1991) and Fortin (1980). Color terms in parenthesis are those of Kornerup & Wanscher (1978).

Results

Scleroderma albidum Pat. & Trab., Bull. Soc. Myc. Fr. 15: 57, 1899. FIGS 1, 5

Basidiomata 2–4 cm wide, subglobose or depressed globose, yellowish white (4A4) with a small rhizomorphic base. Peridium up to 5 mm thick when fresh, becoming thinner when dry, smooth surface, usually dehisced by irregular splitting, from the apex downwards into unequal lobes; branched or unbranched thin walled hyphae, 3–4 μm diam. Gleba pulverulent, dark grey (3F3). Basidiospore globose, echinulate, 12–14 μm diam, dark brown.

HABITAT: On sandy soil, epigeous, aggregated with roots of *Pinus radiata* D. Don in a plantation of this tree.

MATERIAL EXAMINED: **BRAZIL. PERNAMBUCO:** RECIFE, HORTO FLORESTAL DOIS IRMÃOS, 18.VII.2007, I.G. Baseia (URM 307577).

ADDITIONAL MATERIAL EXAMINED: BRAZIL, São Paulo, Campos do Jordão, Parque Florestal, 09/III/1971, G. Guzmán, SP 214722; SP 112060.

DISTRIBUTION: Brazil (Guzmán 1970, Bononi et al. 1981, Giachini et al. 2000), Mexico (Esqueda-Valle et al. 1990).

COMMENTS— *Scleroderma albidum* is characterized by its light brown and smooth peridial wall. It differs from *S. polyrhizum*, which is recognised by the rough surface of the peridium and subglobose spores with smaller spines (Baseia & Milanez 2000). The basidiomes of the material studied were found growing alone or in groups during the rainy season. *S. albidum* was found associated with *Pinus radiata*, an exotic conifer from North America introduced into some Atlantic rainforest areas. Its basidiomes presented rhizomorphs in aggregation with the roots of this tree. The root tips showed typical ectomycorrhiza with mantle and Hartig net. It is reported for the first time in Northeastern Brazil.

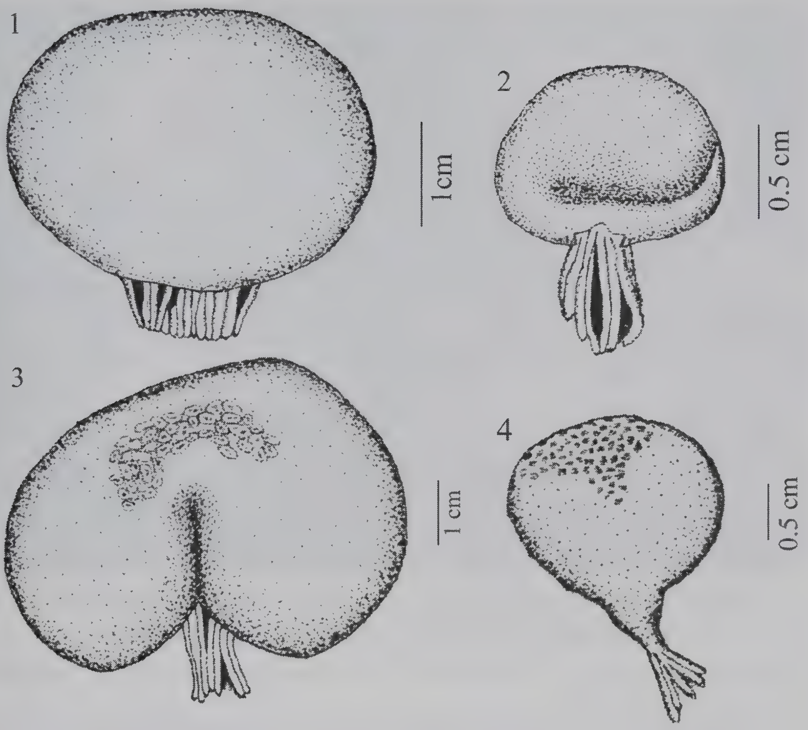


Fig. 1-4. Basidiomata:
1. *Scleroderma albidum*; **2**. *S. bovista;* **3**. *S. citrinum;* **4**. *S. nitidum*

Scleroderma bovista Fr., Syst. Myc. 3: 48, 1829. FIGS 2, 6

Basidiomata 2–3 cm wide, subglobose, irregularly globose to oblate, yellowish brown (5E5). Peridium up to 4–6 mm thick when fresh, becoming thinner when dry, smooth surface, usually dehisced by irregular splitting; thin walled hyphae, unbranched, 3–4 μm diam, clamp connections present. Gleba compact, yellowish brown (6F7). Basidiospore brown, globose, echinulate and reticulate, 9–11 μm diam.

HABITAT: On sandy soil, epigeous, aggregated with roots of *Gomidesia spectabilis* (DC.) O. Berg (*Myrtaceae*), in Atlantic rainforest.

MATERIAL EXAMINED: BRAZIL. PERNAMBUCO: HORTO FLORESTAL DOIS IRMÃOS, 29.VII.2007, I.G. Baseia (UFRN-fungos 456).

ADDITIONAL MATERIAL EXAMINED: BRAZIL, São Paulo, Campos do Jordão, Parque Florestal, 09/III/1971, G. Guzmán, SP 214720.

DISTRIBUTION: Argentina (Spegazzini 1927), USA (Coker & Couch 1928, Richter 1992), South Africa (Bottomley 1948), Norway (Eckblad 1955), Congo (Dissing & Lange 1962), China (Liu 1984), Chile (Garrido 1986), Brazil (Guzmán 1970, Giachini et al. 2000).

COMMENTS— *Scleroderma bovista* is recognised by its smooth peridial surface, differing from *S. albidum* mainly by the basidiospores, which are smaller and reticulate in *S. bovista*. The basidiomata of the material studied were found growing alone or in groups during the rainy seasons associated with *Gomidesia spectabilis,* an ectomycorrhizal tree native to this region. The symbiotic relationship is sustained by rhizomorphs of *S. bovista* in aggregation with the roots of this tree. A mantle and Hartig net, characteristics of ectomycorrhizae, were detected by microscopic analysis. The species is thought to have a wide host range (Guzmán 1970): Garrido (1986) noted an ectomycorrhizal association between this fungus and *Pinus radiata* in Chile and Giachini et al. (2000) noted association with *Pinus* and *Eucalyptus* species. This is the first report of *S. bovista* in Northeastern Brazil.

Scleroderma citrinum Pers., Syn. Meth. Fung. 1: 153, 1801. FIGS 3, 7

Basidiomata, light yellow (4A5), depressed globose, 4–7 cm wide, attached to the soil by a small rhizoidal base. Peridium up to 2–3 mm thick when fresh, surface areolate, dehisced by irregular cracking of the apex; hyphae thin walled, usually unbranched, 2–3 μm diam, clamp connections present. Gleba compact, becoming pulverulent, yellowish brown (5F6). Basidiospores yellowish brown, globose or subglobose, echinulate and reticulate, 12–13 μm diam.

HABITAT: On sandy soil, epigeous in a *Pinus taeda* L. plantation, aggregated with roots of this tree.

MATERIAL EXAMINED: **BRAZIL. PARAÍBA:** JOÃO PESSOA, JARDIM BOTÂNICO, 11.VII.2006, I.G. Baseia (UFRN-fungos 502).

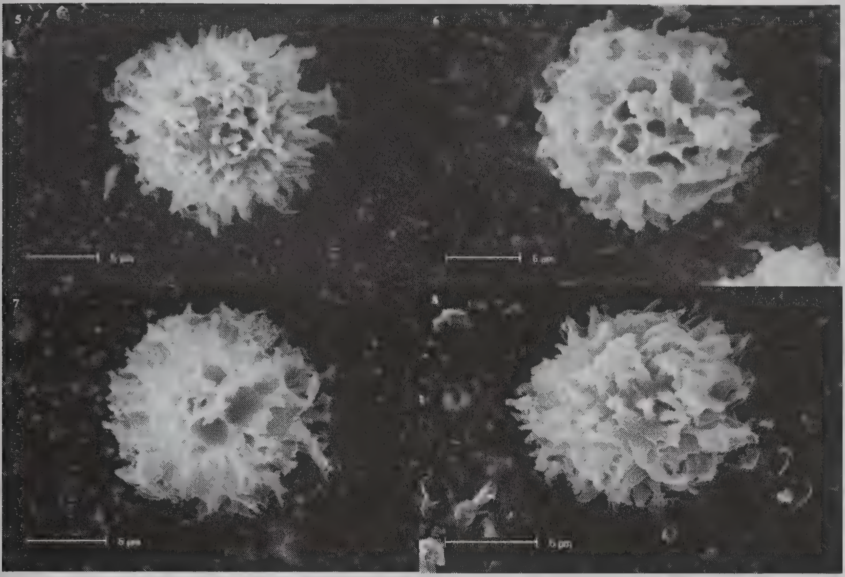
ADDITIONAL MATERIAL EXAMINED: USA, Maryland, 21/VII/1958, G. Guzmán, SP 50636.

DISTRIBUTION: Spain (Calonge & Demoulin 1975), Brazil (Guzmán 1970, Bononi et al. 1981, Giachini et al. 2000), China (Liu 1984), Chile (Garrido 1986), USA (Richter 1992).

COMMENTS— *Scleroderma citrinum* is characterized by its large yellowish white basidiomata and peridium with areolate surface. The basidiomata were found growing abundantly during the rainy seasons in ectomycorrhizal association with *Pinus taeda*. Garrido (1986) found an ectomycorrhizal association between this fungus and *Pinus radiata* in Chile, demonstrated by pure culture synthesis. During our fieldwork we observed that *S. citrinum* was the most common *Scleroderma* species in the pine plantation. This is the first report of this fungus in Northeastern Brazil.

Scleroderma nitidum Berk., Hook J. Bot. 6: 173, 1854. FIGS 4, 8

Basidiomata yellowish brown (5D5), subglobose, 1.5–3 cm wide. Peridium up to 4–5 mm thick when fresh, becoming thinner when dry, verrucose surface, dark



Figs. 5-8. SEM pictures of basidiospores:
5. *Scleroderma albidum;* **6.** *S. bovista;* 7. *S. citrinum;* **8.** *S. nitidum*

brown (6F6), evenly scattered on a surface that dehisced by irregular splitting; hyphae thin-walled, hyaline, 10–18 × 6–12 µm. Gleba pulverulent, olive grey (3F3). Basidiospore dark brown, globose, echinulate, 11–12 µm diam.

Habitat: On sandy soil, epigeous under *Coccoloba* sp.

Material examined: **BRAZIL. Paraíba:** João Pessoa, Jardim Botânico, 24.VII.2007, I.G. Baseia (UFRN-fungos 464). **Pernambuco:** Recife, Horto Florestal Dois Irmãos, 15.VI.2007, I.G. Baseia (UFRN-fungos 494). **Bahia:** Senhor do Bofim, 17.III.2006, I. Gusmão (UFRN-fungos 500). **Rio Grande do Norte:** Natal, Parque das Dunas, 03.V.2007, F.E. Gurgel (UFRN-fungos 491).

Additional material examined: USA, Maryland, VII/1958, D. M. Dring, SP 55938; AFRICA, SIERRA LEONE, 22/VI/1965, G. Guzmán, SP 107416.

Distribution: Argentina (Spegazzini 1927), South Africa (Bottomley 1948), Norway (Eckblad 1955), Panama (Garner 1956), Brazil (Rick 1961, Guzmán 1970, Giachini et al. 2000), Congo (Dissing & Lange 1962), Spain (Calonge & Demoulin 1975), China (Liu 1984), Chile (Garrido 1986), Mexico (Pardavé 1991), Belgium (Moyersoen & Demoulin 1996).

Comments — This species is usually easy to distinguish by its yellowish brown and soft peridium, covered by dark brown verrucae at least over the upper part,. It is close to *S. citrinum* but differing in the colour and consistency of the peridium. The basidiomata were found growing in groups during the rainy seasons in ectomycorrhizal association with the native tree, *Coccoloba* sp. Its roots tips showed typical ectomycorrhiza with mantle and Hartig net. This is the first report of *S. nitidum* in Brazil.

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Description of *Tuber malenconii* mycorrhizae and a comparison with mycorrhizae of *T. aestivum* and *T. mesentericum*

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Abstract — *Tuber malenconii* is a recently described uncommon European truffle associated with *Quercus ilex* that is potentially detrimental to the cultivation of the highly prized edible, *T. melanosporum*. Examination of *T. malenconii* mycorrhizae synthesized from fresh ascocarps revealed polygonal mantle cells and numerous cystidia with basal-forked ramifications. Differences between *T. malenconii, T. mesentericum,* and *T. aestivum* mycorrhizae are noted; compound and scanning electron micrographs provide additional comparisons.

Key words — *Tuberaceae*, ectomycorrhizae, hypogeous fungus

Introduction

The recently described truffle, *Tuber malenconii,* is a rather rare species that has been reported from France (Donadini et al. 1979, Riousset et al. 2001), Italy (Montecchi & Sarasini 2000), and Spain (Álvarez et al. 1993). *T. malenconii* inhabits warm regions in clay brown calcareous soils under *Quercus ilex* L. This truffle has an unpleasant faecal odour and therefore no economic value. The fact that *T. malenconii* has been collected in cultivations of the highly prized black truffle, *T. melanosporum* Vittad., in France and Spain suggests that it is a potential competitor that might be detrimental to *T. melanosporum* carpophore production. García-Montero et al. (1996) and Manjón & García-Montero (1996) have cited the synthesis of *T. malenconii* mycorrhizae and have expressed concern for the risk that this species would pose to *T. melanosporum* should it be introduced (accidentally or otherwise) into truffle plantations.

It is the usual practice to carry out quality control in nurseries that produce mycorrhized plants for truffle culture. Several authors have detailed the morphology of the mycorrhizae of economically valuable *Tuber* species (Zambonelli et al. 1993, Granetti 1995). However, in order to establish efficient quality controls of mycorrhized plants, we need to know more about all *Tuber* mycorrhizae, as demonstrated in the comparisons between the similar ectomycorrhizae representing some Chinese *Tuber* species and *T. melanosporum* (Di Massimo et al. 1996, Comandini & Pacioni 1997, Zambonelli et al. 1997, Manjón et al. 1998, García-Montero et al. 2008). Accordingly, we describe the morphology of *T. malenconii* ectomycorrhizae, which we then compare with the similar mycorrhizae of *T. aestivum* Vittad. and *T. mesenterica* Vittad..

Material and methods

We synthesized *Tuber malenconii* ectomycorrhizae using carpophores gathered in Villafranca (Castellón province, Spain). Part of the material was preserved in the herbarium of the University of Alcalá (AH-20004). We synthesized ectomycorrhizae of *T. malenconii*, *T. aestivum*, and *T. mesentericum* with *Quercus ilex* subsp. *ballota* (Desf.) Samp. plants according to Bencivenga (1982) and modified by Manjón & García-Montero (1996). Plants were kept under controlled environmental conditions in the Juan Carlos I Royal Botanical Garden at the University of Alcalá (Madrid, Spain). The degree of mycorrhization of each plant was expressed as the number of *Tuber* mycorrhizae per total number of apices counted (Bencivenga et al. 1987). Ectomycorrhizae were identified with a stereoscopic microscope (photo-Leica WildMZ8) and compound microscope (photo-Leica LeitzDMRB) following the recommendations proposed by Agerer (1987–2002), Zambonelli et al. (1993), and Granetti (1995). Each character was measured by taking measurements until regularity was attained in the values observed.

Ectomycorrhizae

Our techniques for inoculating and producing mycorrhized plants, as well as the substrates used, gave good results for both *Tuber malenconii* and *T. melanosporum.* The six seed *Quercus ilex* subsp. *ballota* plants mycorrhized with *Tuber malenconii* showed a 50% mycorrhization average (standard deviation = 14) of all root apices when other fungal ectomycorrhizae were not present, while the six seed plants mycorrhized with *T. melanosporum* averaged a 62% (standard deviation = 16) coverage, also without ectomycorrhizae of other fungi. The *T. malenconii* ectomycorrhizae (Figs. 1–4) were concentrated above all in the proximal and median part of the root system.

Tuber malenconii Donadini, Riousset, G. Riousset & G. Chev. FIG. 1

FORM AND MODE OF RAMIFICATION: from slightly club-shaped to almost cylindrical, or with monopodial-pinnate ramifications, without ramifications in very young forms; UNRAMIFIED ENDS: 1500–3500 µm long, 580–720 µm diam, straight, color ochre, darker in the central mycorrhiza, very clear in the apical part, darkening in age; STRUCTURE OF THE SURFACE: smooth, with numerous long cystidia that give it a woolly appearance, more abundant at the apex of the young mycorrhizae and at the centre and base of the mature mycorrhizae; the old mycorrhizae may be free of mycelium; RHIZOMORPHS: absent.

Emanating hyphae

CYSTIDIATE with a very long sinuous shape, septate, unbranched; widths 2–3 µm diam, lengths 15–30 µm, very variable; colour yellowish. SURFACE smooth or occasionally with mammellate incrustations, the termination is rounded and simple but may be widened by the presence of these incrustations. HYPHAE RAMIFICATIONS: the hyphal insertion point into the mantle may be simple, slightly widened, or ramified. A single hypha may grow out of the mantle or immediately branch into two forming a typical "Y" shape; sometimes two hyphae emerge from one point. Such ramifications were observed only near the hyphal insertion into the mantle, after which no further branching was observed. PERCENTAGE OF THE KIND OF HYPHAE: on the basis of the counts made we can establish 60% hyphae with non basal-forked ramifications (= forked ramifications at the base), 30% cystidia with basal-forked ramifications, and 10% doubtful hyphae due to difficulty of observation.

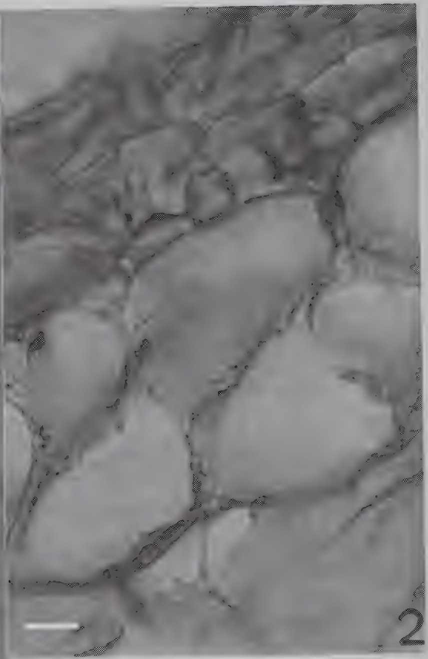
Anatomical characters of the outer mantle

STRUCTURE: pseudoparenchymatous with most of the pseudocells polygonal with 4 to 5 sides, alternating with some cells with a sinuous form; DIMENSIONS OF HYPHAL PSEUDOCELLS: (3)4–10(11) × (3)4–8(9) µm.

Anatomical characters — cross section

THICKNESS AND DIFFERENTIATION: mantle is 10–30 µm thick, a thin (3–10 µm thick) outermost layer can be differentiated where the hyphal cells are more compact; CELL SHAPE AND DIMENSIONS: the outermost layer cells are very difficult to measure; the remaining mantle is composed of cells that are either rounded and then 8–15 × 4–9 µm or angular with a tangential orientation.

1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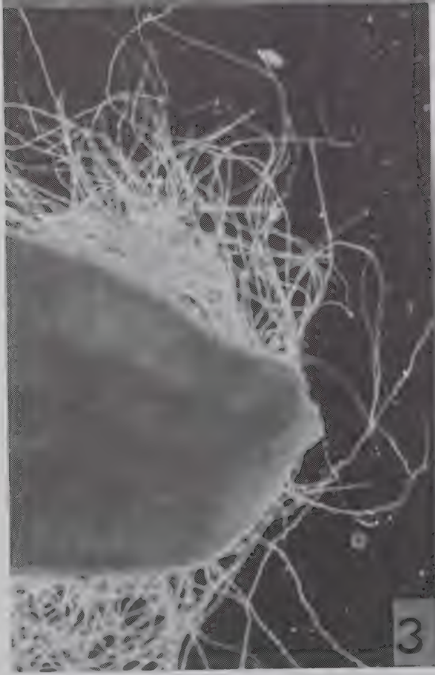
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TANNIN CELLS 1–2 rows, sometimes forming a 3–6 µm thick continuous layer, individual cells averaging 5–14 × 2–5 µm. CORTICAL CELLS of two shapes, either rounded (18–24 × 18–22 µm) or rectangular (35–50 × 20–30 µm). HARTIG NET present in 2–3 rows to a depth of 40–60 µm; THICKNESS: 2-4 µm; SHAPE OF HYPHAL CELLS AND DIMENSIONS: rounded/rectangular, 2–4 × 1–1.5 µm.

Table 1. Discriminating features among *Tuber malenconii, T. aestivum,* and *T. mesentericum* ectomycorrhizae

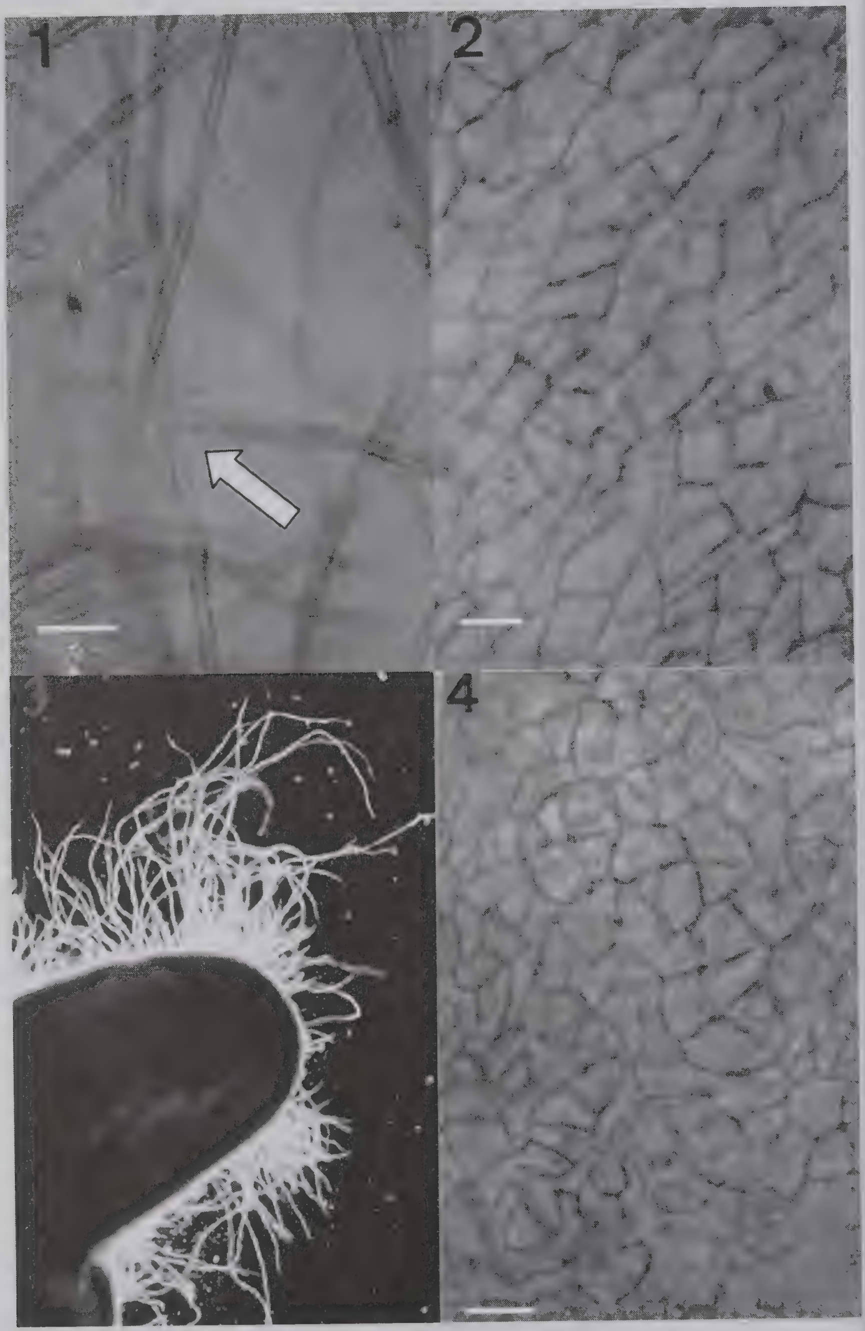
SPECIES	*T. malenconii*	*T. aestivum*	*T. mesentericum*
UNRAMIFIED ENDS			
Length	≤ 3500 µm	≤ 8500 µm**	≤ 3800 µm**
Diameter	≤ 720 µm	≤ 400 µm**	≤ 300 µm**
MANTLE OUTER STRUCTURE	Polygonal pseudocells with rounded angles	Polygonal pseudocells with rounded angles*	Polygonal pseudocells with sharp angles* (secondarily diagnostic**)
CYSTIDIA			
Form	Without intercalary thickenings	With intercalary thickenings.* (sporadic**)	Without intercalary thickenings*
% with basal-forked ramifications	30 %	None**	5-10 % **

* Zambonelli et al. (1993); ** Granetti (1995).

Discussion

Tuber malenconii ascocarps are readily diagnosed by their characteristic 8-spored asci and ascospores with a regular reticulate-alveolate ornamentation consisting of small, dense meshes. Unfortunately, the mycorrhizae of *T. malenconii, T. aestivum,* and *T. mesentericum* are morphologically very similar: all three produce numerous long cystidia that cover most of the mycorrhizal surface and outer mantle pseudocells with a polygonal form (Table 1; Zambonelli et al. 1993, Granetti 1995). In fact, *T. aestivum* and *T. mesentericum* mycorrhizae are so similar (Fig. 2) that *T. mesentericum* can be

Fig 1 (left). *Tuber malenconii* (bar = 10 µm). Fig. 1.1. Hyphal pseudocells from the outer surface of the mantle with polygonal shape, with roundish angles (1000 x). Fig. 1.2. Hartig net (1000 x). Fig. 1.3. Macroscopic aspect of the mycorrhizae (100 x). Fig. 1.4. Detail of cystidium with basal-forked ramifications (1000 x).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separated from *T. aestivum* only by noting that a consistantly small percentage (5–10%) of the cystidia fork at the bases (Di Massimo et al. 1995, Granetti 1995), a character not seen in *T. aestivum* mycorrhizae. This forking is not confined to *T. mesentericum* mycorrhizae, however, as an even greater percentage (30%) of cystidia in *T. malenconii* mycorrhizae produce basal-forked ramifications (Fig 1.4). The differences in the degree of basal forking among three species suggest that the character may have diagnostic potential in developing taxonomic keys to all *Tuber* mycorrhizae. Such a key would be helpful in creating new quality control protocols established to ensure that the mycorrhized plants have not become contaminated by undesirable species during the truffle culture process.

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Fig. 2. *Tuber mesentericum* (bars = 10 μm). Fig. 2.1. Detail of cystidium with basal-forked ramifications (1000 x). Fig. 2.2. Hyphal pseudocells from the outer surface of the mantle with polygonal shape, with sharp angles (1000 x). Fig. 2.3. *T. aestivum*. Macroscopic aspect of the mycorrhizae (100 x). Fig. 2.4. Hyphal pseudocells from the outer surface of the mantle with polygonal shape, with roundish angles (1000 x) (the white segments represent 10 μm).

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MYCOTAXON

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An albino form of *Auricularia fuscosuccinea* from Lacandonia tropical forest, Chiapas, Mexico

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Abstract – An albino form of *Auricularia fuscosuccinea* is described from Chiapas tropical forest in Mexico. The taxonomy of *Auricularia* species is briefly reviewed.

Key words – *Auriculariaceae*, biological diversity, Neotropics.

Introduction

According to Ainsworth & Bisby's Dictionary of the Fungi (Kirk et al. 2001), there are approximately 15 recognized species of *Auricularia* Bull. ex Juss., represented by 124 species names listed in the Index of Fungi. Proliferation of most species names occurred prior to Lowy (1951) at a time when species were delimited based primarily on basidiome size, shape and color and the length of abhymenial hairs (Saccardo 1888, 1895; Barrett 1910; Burt 1921; Kobayasi 1942). Teixeira (1945) utilized the medulla, a central zone of compact, parallel hyphae that may be observed in transverse sections of basidiomata in addition to the above features. Lowy (1951) suggested that the traditional characters of basidiome size, shape and color varied with age and environmental conditions and should, therefore, not be considered of primary taxonomic importance. Instead, Lowy (1951, 1952) selected the presence/absence of the medulla, the medullary width when present, and abhymenial hair length as features that he believed to be stable and not significantly affected by age and changes in environmental conditions. Lowy (1951, 1952) used these characters to delimit species, recognizing ten species and reducing most of the names to synonymy.

While most workers (e.g. Cheng & Tu 1978, Kobayasi 1981) have followed Lowy (1951, 1952), Olive (1958) and Raitviir (1971) questioned the value of the characters utilized by Lowy (1951, 1952) to define species.

Kobayasi (1981), who described 15 species and 5 forms of *Auricularia*, listed three albino forms: *A. auricula* f. *albicans* (Berk.) Kobayasi (= *A. auricula-judae* var. *lactea* Quél.), *A. delicata* f. *alba* Kobayasi, and *A. polytricha* f. *leucochroma* (Kobayasi) Kobayasi. Li & Liu (1985) described one albino collection as a new species, *A. eburnea,* and Wong (1989) described an albino form of *A. cornea*.

Albino forms of *Auricularia* have not been previously reported in neotropical regions by Lowy (1971, 1980) nor in Mexico by Lowy (1965), Mendiola & Guzman (1973), Pérez-Silva & Esqueda-Valle (1992) and Sierra & Cifuentes (1993).

Material and methods

The specimens were collected and studied using standard mycological techniques (Martin 1952, Lowy 1971, Cifuentes et al. 1986, Sierra 1992), and with specimens deposited in FCME. Color numbers are from Methuen Handbook of Colour (Kornerup & Wanscher 1978).

Taxonomy

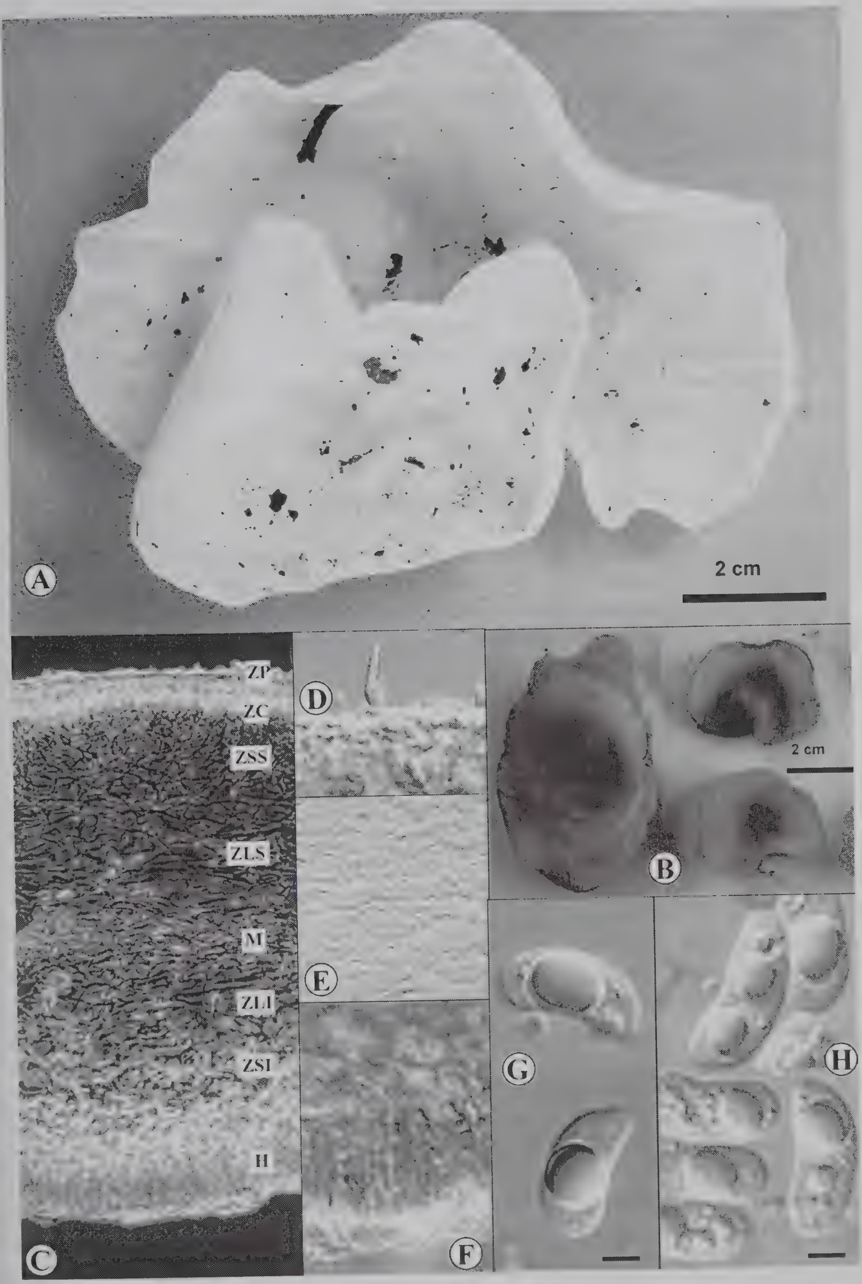
Auricularia fuscosuccinea (Mont.) Henn.
"Lacandon albino form" FIGURE 1

Basidiomes orbicular, c. 8 cm in diameter, context thin. White when fresh (Methuen 2A2 to white); semitransparent when dry. Upper surface smooth, with scattered hairs 30–65 × 4–6 µm, with acute tips. Medulla a single band of hyphae centrally oriented. Basidia up to 60 × 3.5 µm; basidiospores curved-cylindrical, 10–13 × 4–5 µm. Germination not observed.

ECOLOGY, RANGE AND DISTRIBUTION: Lignicolous, on unidentified rotten wood. Found in hot and humid tropical forest habitat with rain year-round except for a short dry season in March and April. Median annual precipitation of 2400 mm.

SPECIMEN EXAMINED – **MEXICO. CHIAPAS – Municipio de Ocosingo**, Lacanjá-Chansayab, located at 16°46'08" north, 96°08'12" west, alt. 350 m – 24.I.2004 Ruan-Soto 46 (FCME 22561).

FIGURE 1: *Auricularia fuscosuccinea.* A. Basidiome (albino form). B. Basidiome (typical form). C. Section of basidiome (abbreviations: ZP: Zona pilosa; ZC: Zona compacta; ZSS: Zona subcompacta superioris; ZLS: Zona laxa superioris; M: Medullae; ZLI: Zona laxa inferioris; ZSI: Zona subcompacta inferioris; H: Hymenium). D. Hairs. E. Medulla hyphae. F. Hymenium. G. & H. Spores (G. albino form). (H. typical form). Scale bar G & H = 5 µm.


A
2 cm
ZP
ZC
ZSS
ZLS
M
ZLI
ZSI
H
C
D
E
F
B
2 cm
G
H

Additional specimen examined – **MEXICO. CHIAPAS – Municipio de Ocosingo,** Lacanjá-Chansyab. 18.VI.2004. Ruan-Soto 156 (FCME 22586), typical form of *A. fuscosuccinea.*

Comments – This albino form differs from the typical form only in colour. *A. fuscosuccinea* "Lacandon albino form" is very easy to differentiate from the albino form of *A. cornea* (= *A. polytricha*) described by Wong (1989) by its short hairs (until 65 µm) and from *A. auricula-judae* v. *lactea* and *A. delicata* f. *alba* by the presence of medulla. *A. eburnea* discribed by Li & Liu (1985) is different in spores (15.6–18 × 5.5–7.5 µm) and hair size (280–380(–450) µm). This fungus is rare. People in the region where it is found speak Lacandon (Levy-Tacher 2000). The Lacandon name of this fungus is Sak're lo'ro (Sak're = white and lo'ro = all species of *Auricularia*). The fungus is regarded as edible; the Lacandons eat it fried in a "comal" (a kind of frypan) or prepare a dish with *Auricularia* and bean stock. This is the first published record of a white *Auricularia* in Mexico.

Acknowledgements

We wish to thank Dr. Peter Roberts, Dr. George J. Wong and Dr. Peter Buchanan for reviewing the manuscript and for helpful comments; Mr. Manuel Castellanos Chan Kin for his helpful guidance in the rain forest. M.S. Diego Hernan Valencia Korosi for reviewing the English manuscript. This research was supported by DGAPA IN-209605 and IN-218008.

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Validation of *Repetobasidiopsis* and *Trimitiella* (*Basidiomycetes*)

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Abstract — In their original publications, *Repetobasidiopsis grandisporus* and *Trimitiella indica* were referenced to holotypes deposited in two different herbaria. To ensure the validity of the generic names *Repetobasidiopsis* and *Trimitiella* and the species names, one herbarium (PAN) is designated for each holotype in accordance with ICBN Article 37.7.

Key words — nomenclature

Dhingra (2006) and Dhingra & Singh (2006) proposed the new genera *Trimitiella* and *Repetobasidiopsis* to accommodate two new species, *Trimitiella indica* and *Repetobasidiopsis grandisporus* respectively. In the protologues, two different herbaria were cited for each holotype — PAN and LY for *T. indica* and PAN and GH for *R. grandisporus*. However, Art. 37.7 of the International Code of Botanical Nomenclature (McNeill et al. 2006) states, "For the name of a new species or infraspecific taxon published on or after 1 January 1990 of which the type is a specimen or unpublished illustration, the single herbarium or collection or institution in which the type is conserved must be specified." Because two herbaria were designated for holotype collections for each type species, the generic and species names were invalidly published.

Therefore we validate below *Repetobasidiopsis*, *Repetobasidiopsis grandisporus*, *Trimitiella* and *Trimitiella indica* by designating the specimens held in PAN as **holotypes** and those held in LY and GH as **isotypes**. According to Art. 36.1, it is unnecessary to repeat the Latin diagnoses, but refer to those published in Dhingra (2006) and Dhingra & Singh (2006).

Repetobasidiopsis Dhingra & Avneet P. Singh, **gen. nov.**
Mycobank MB501457
"*Repetobasidiopsis*" Dhingra & Avneet P. Singh,
Mycotaxon 97: 115, 2006 (inval. Art. 37.7).
Typus: *Repetobasidiopsis grandisporus* Dhingra & Avneet P. Singh

Repetobasidiopsis grandisporus Dhingra & Avneet P. Singh, **sp. nov.**
MYCOBANK NO. MB501362
"*Repetobasidiopsis grandisporus*" Dhingra & Avneet P. Singh, Mycotaxon 97: 116, 2006 (inval. Art. 37.7).

Holotypus: G.S. Dhingra 19706 (PAN; ISOTYPE at GH)

Trimitiella Dhingra, **gen. nov.**
MYCOBANK NO. MB501458
"*Trimitiella*" Dhingra, Mycotaxon 97: 125, 2006 (inval. Art. 37.7).

Typus: *Trimitiella indica* Dhingra

Trimitiella indica Dhingra, **sp. nov.**
MYCOBANK NO. MB501367
"*Trimitiella indica*" Dhingra, Mycotaxon 97: 126, 2006 (inval. Art. 37.7).

Holotypus: G.S. Dhingra 19722 (PAN; ISOTYPE at LY).

Acknowledgments

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New and unusual hyphomycetes from Mahabaleshwar, India

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Abstract – Three conidial fungi, *Tetraploa circinata* sp. nov., *Vamsapriya mahabaleshwarensis* sp. nov. and *Gliophragma setosum*, isolated from plant litter and collected at Mahabaleshwar, Maharashtra, India, are described and illustrated.

Key words – biodiversity, anamorphic fungi, taxonomy, Western Ghat forests

Introduction

During the course of our studies on microfungi of the forests of Western Ghats, two new dematiaceous hyphomycetes, *Tetraploa circinata* and *Vamsapriya mahabaleshwarensis*, were isolated from fallen litter collected from Mahabaleshwar, southern India. *Tetraploa circinata* is unique in its long, spirally coiled, verrucose appendages. *Vamsapriya mahabaleshwarensis* differs from the only previously described species in this genus by its branched conidial chains developing on polytretic conidiogenous cells. *Gliophragma setosum*, a rare conidial fungus, was also isolated during the course of this study.

Taxonomic descriptions

Tetraploa circinata Pratibha & Bhat, **sp. nov.** Figs. 1, 2

MycoBank MB 512004

Ad fungos conidiales, hyphomycetes. Coloniae in substrato naturali effusae, atrobrunneae vel nigrae. Mycelium superficialia, ex hyphis laevibus, pallide brunneis, ramosis, septatis, 2.5–3 µm lat. compositum. Setae et hyphopodia absentia. Conidiophora micronematica, ramosa, atrobrunnea. Cellulae conidiogenae monoblasticae, incorporatae. Conidia ex corpore muriforme et appendicibus quatuor composita, solitaria, sicca, atrobrunnea, conidiorum sunt 2 formae; conidia priora ex 4 columnis compositum, 13–15 × 21–26

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*Current address: Myko Tech Pvt. Ltd. [Plot No. 12, Mapusa Industrial Estate, Dattawadi Mapusa, Goa 403507, India]

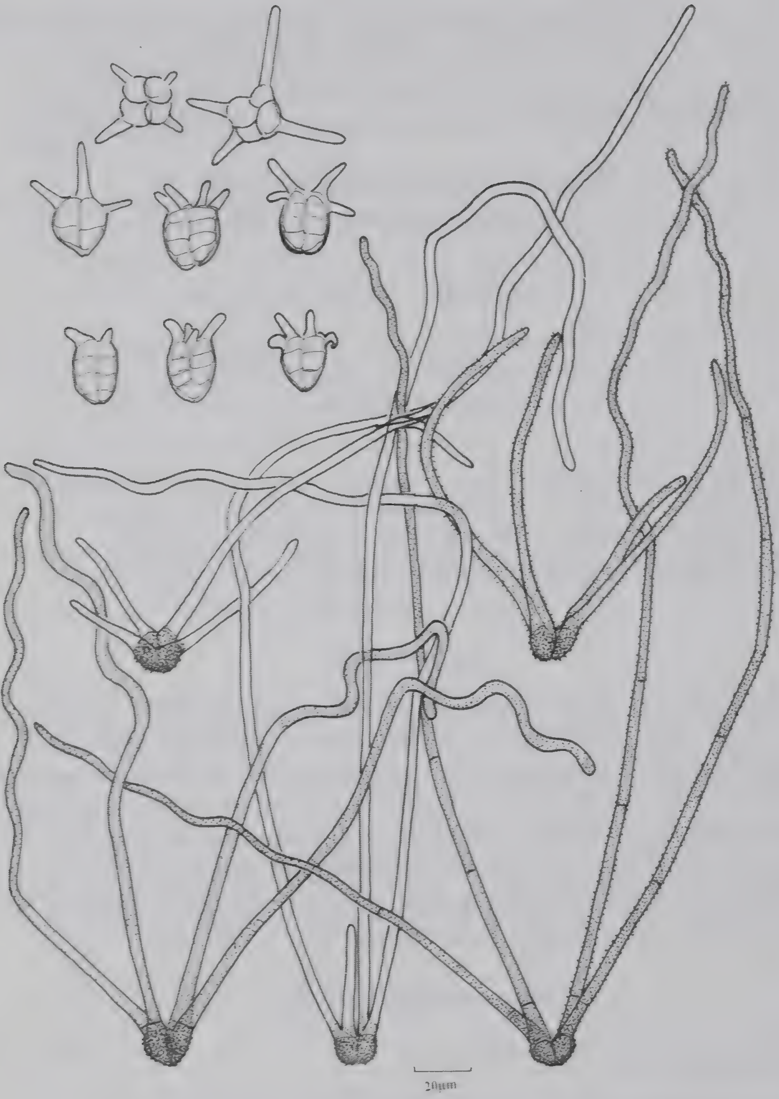
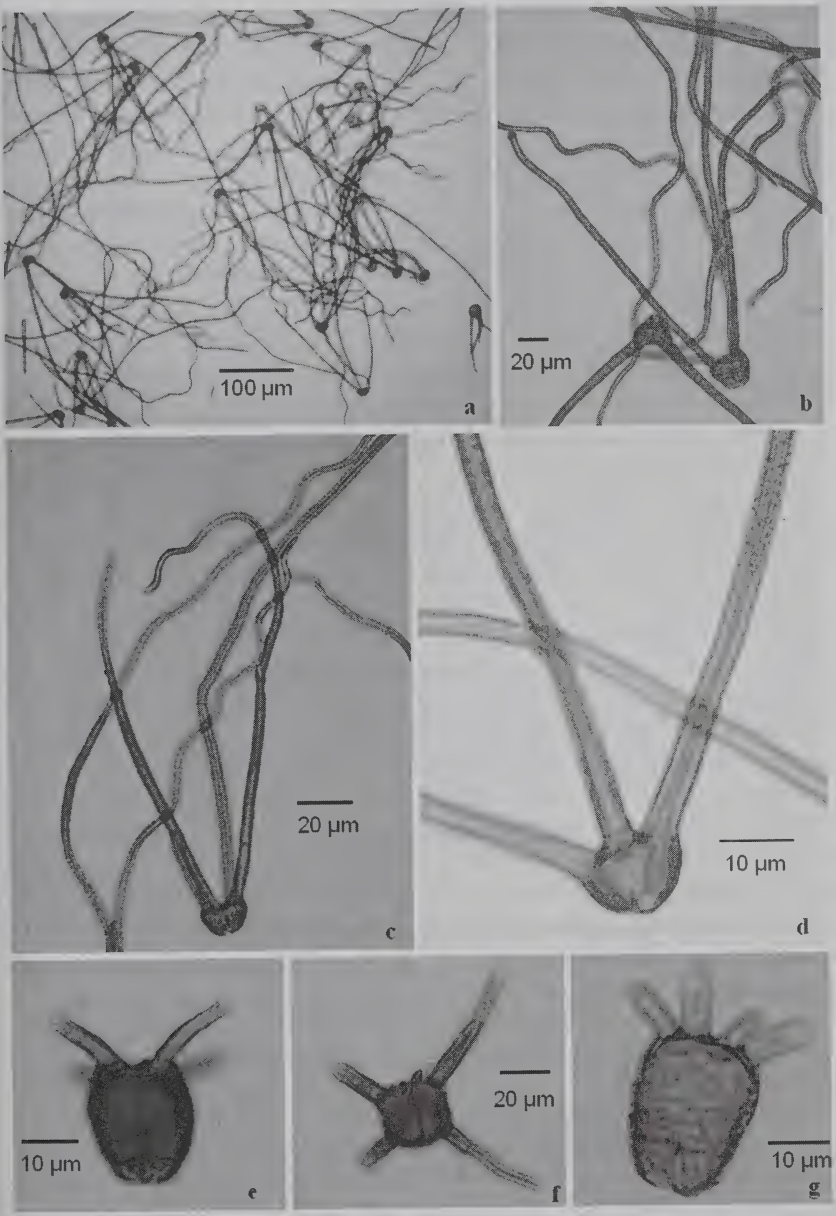


Fig. 1. ***Tetraploa circinata*.** Two types of conidia.

µm, columnae 5–7 µm lat., divergentibus ad apicem, appendices spirales, verruculosae, atrobrunneae, 54–415 × 3–3.5 µm; conidia cetera ex 4 columnis compositum, 15–24 × 12–22 µm, appendices laeviae, 5–22 µm longa, 2–4 µm lat.; columnae 8–10 µm lat.

HOLOTYPE: On dead, decaying bamboo twig, 04/11/2006, J. Pratibha, Mahabaleshwar, Maharashtra, India, Herb. No. HCIO 48133 (Isotype: GUBH MH3)


100 µm
a
20 µm
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20 µm
c
10 µm
d
10 µm
e
20 µm
f
10 µm
g

FIG. 2. ***Tetraploa circinata.***
a–d. First type of conidia with long, spiral, verrucose, appendages;
e–g. Second type of conidia with short, smooth appendages.

Conidial fungi, hyphomycetes. Colonies on natural substrate effuse, dark brown to black. Mycelium partly superficial, composed of septate, branched, light brown, smooth hyphae 2.5–3 µm wide. Setae and hyphopodia absent. Conidiophores micronematous, branched, dark brown, forming an entanglement on the substrate. Conidiogenous cells monoblastic, undifferentiated from conidiophores. Conidia consisting of a dictyosporous body and four appendages, solitary, dry, dark brown, of two morphological types; first type 13–15 µm long, 21–26 µm wide, consisting of four columns each of 1–2 cells, columns 5–7 µm wide, each terminating apically in a long, spiral or sinuate, verrucose, dark brown appendage, 54–415 × 3–3.5 µm; second type of conidia 15–24 µm long, 12–22 µm wide, consisting of four columns each of 2–5 cells, columns 8–10 µm wide, with short, smooth, apical appendages 5–22 µm long and 2–4 µm wide.

Notes: The genus *Tetraploa* was established by Berkeley & Broome in 1850 with *T. aristata* Berk. & Broome as type species. So far 11 species and 2 varieties are accommodated in the genus: *T. abortiva*, *T. aristata* var. *aristata*, *T. aristata* var. *sacchari*, *T. biformis*, *T. curviappendiculata*, *T. divergens*, *T. ellisii*, *T. javanica*, *T. longissima*, *T. muscicola*, *T. scabra* and *T. setifera* (Revay 1993, Matsushima & Matsushima 1996, Hatakeyama et al. 2005, Anonymous 2008). The genus is characterized by conidia that are sessile, solitary, brown, verruculose, tetra-columnar, with shallow furrows between the columns; the columns diverge from one another apically and each terminates in an arm or appendage which is setiform, septate and tapering at the tip (Ellis 1949, 1971). Of the known species, *T. aristata,* with two types of conidia and long appendages, bears some similarity to *T. circinata*. In *T. aristata,* the first type of conidia are 25–39 × 14–29 µm with smooth appendages 12–80 × 4.5–8 µm while the second type of conidia, which consist of only 2 columns of cells, are 8–18 × 7–12 µm with smooth appendages 80–330 × 3–6 µm. In *T. circinata* the first type of conidia are 13–15 × 21–26 µm with long, spiral, verrucose appendages, 54–415 × 3–3.5 µm and the second type of conidia are 15–24 × 12–22 µm with short, smooth appendages, 5–22 × 2–4 µm.

Vamsapriya mahabaleshwarensis Pratibha & Bhat, **sp. nov.** Figs. 3, 4
MycoBank MB 512005

Ad fungos conidiales, hyphomycetes. Coloniae in substrato naturali effusae, atrobrunneae vel nigrae. Mycelium substrato immersum, ex hyphis laevibus, pallide brunneis, ramosis, septatis, 2.5–3 µm latis compositum. Setae et hyphopodia absentia. Synnematica erecta, recta vel flexuosa, atrobrunneae vel nigrae, apice divergentibus composita, 655–1150 µm longa, 100–150 µm lat. ad basim, 15–45 µm lat. ad medio, 30–80 µm lat. ad apicem. Conidiophora macronematica, synnematica, septata, ramosa, atrobrunneae, laevia. Cellulae conidiogenae polytreticae, integratae vel discretae, terminaliae vel intercalares,

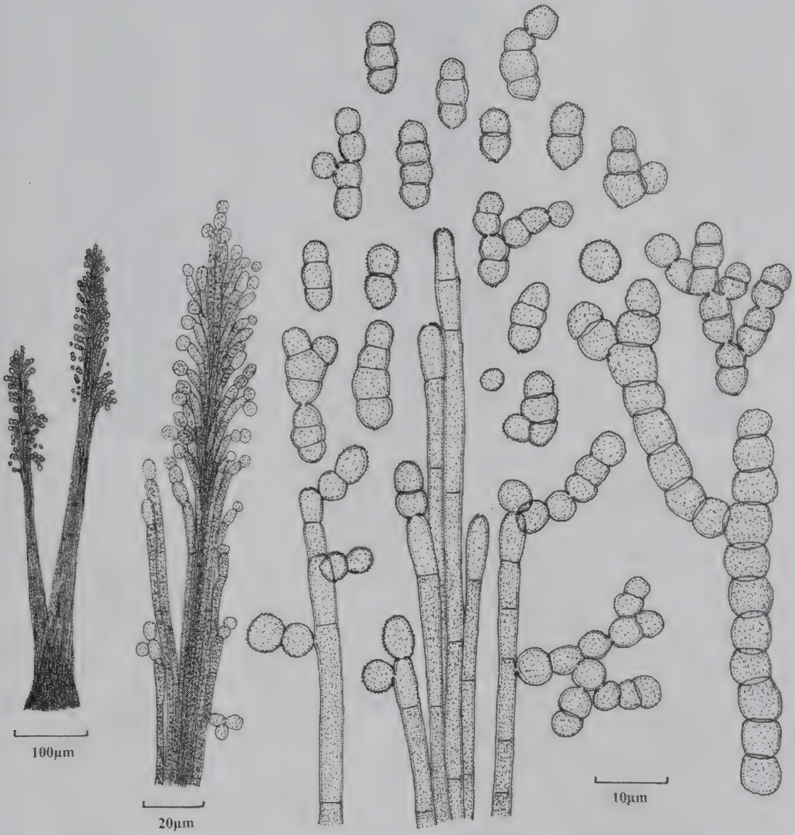

FIG. 3. ***Vamsapriya mahabaleshwarensis.*** Synnemata, conidiogenous cells and conidia.

nunquam cicatricem, pallide brunneae, 6–23 × 3–5 µm. Conidia sicca, catenulata, laevia vel verruculosa, 0–4-septata, ad septa constricta, ovoidea, ellipsoidea vel oblonga, utrinque rotundata, 5–25 × 4–9 µm.

HOLOTYPE: On unidentified dead twig, 04/11/2006, J. Pratibha, Mahabaleshwar, Maharashtra, India, Herb. No. HCIO 48134. (Isotype: GUBH MH4)

Conidial fungi, hyphomycetes. Colonies on natural substrate effuse, dark brown to black. Mycelium immersed in the substrate, composed of septate, branched, light brown, smooth, 2.5–3 µm wide hyphae. Setae and hyphopodia absent. Synnemata erect, straight to flexuous, dark brown to black, diverging at the apex, 655–1150 µm long, 100–150 µm wide at the base, 15–45 µm wide in the middle, 30–80 µm wide at the apex. Conidiophores macronematous,

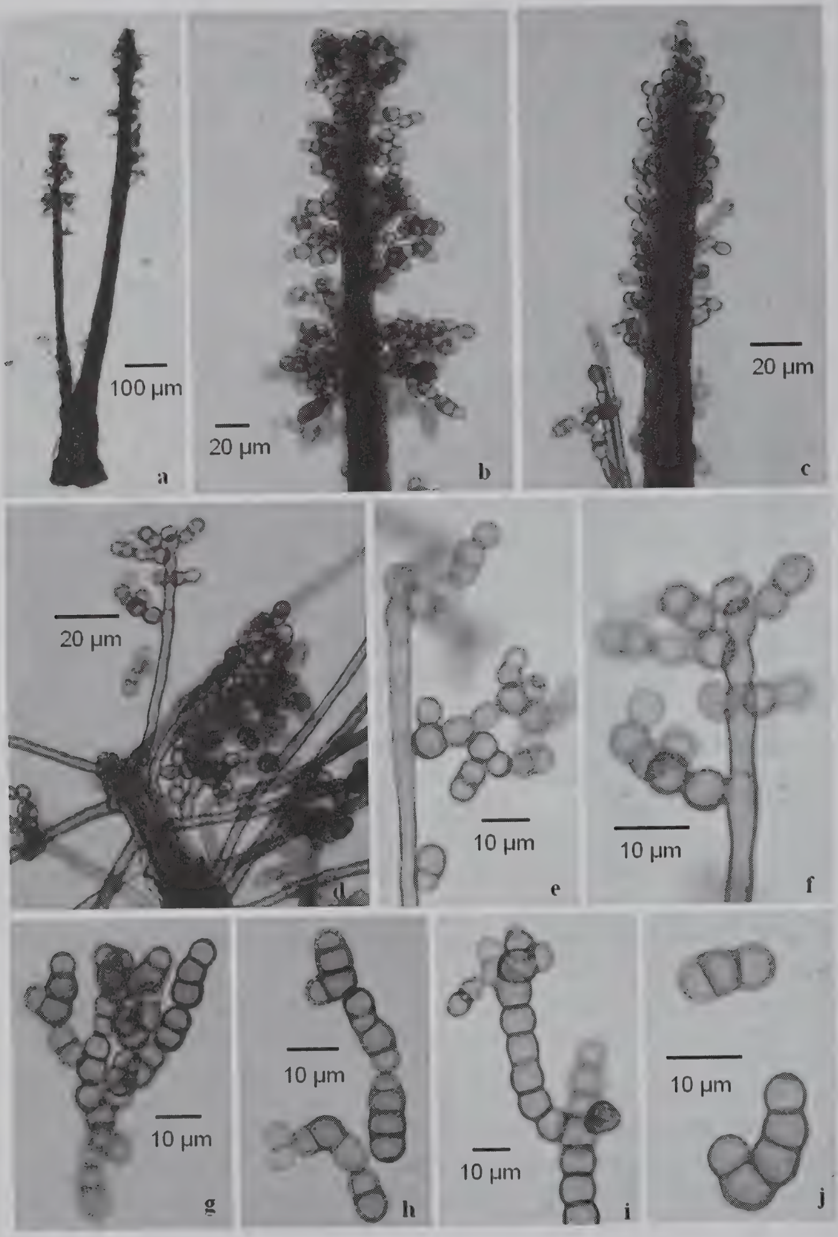
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FIG. 4. *Vamsapriya mahabaleshwarensis.*
a. Synnemata; b–c. Fertile apical region;
d–f. Conidiophores with polytretic conidiogenous cells and conidia;
g–j. Catenate conidia with branched chains.

synnematous, septate, branched, dark brown, smooth. Conidiogenous cells polytretic, integrated or discrete, terminal or intercalary, non-cicatrized, light brown, 6–23 × 3–5 µm. Conidia dry, catenate, smooth to minutely verruculose, 0–4-septate, constricted at the septa, ovoid, ellipsoidal or oblong, rounded at both ends, 5–25 × 4–9 µm, developing in branched chains which secede easily.

NOTES: The monotypic genus *Vamsapriya* was established by Gawas & Bhat, with *V. indica* as type, to accommodate conidial fungi with catenate, phragmosporous conidia on synnematous conidiophores with non-cicatrized, monotretic, conidiogenous cells (Gawas & Bhat 2005). *Vamsapriya mahabaleshwarensis* differs from the type species by formation of polytretic conidiogenous cells and branched conidial chains. Conidia in *V. indica* are smooth, 2–12-septate, 10–80 × 4–6 µm, whereas in *V. mahabaleshwarensis* they are smooth to minutely verruculose, mostly 0–4-septate, rarely up to 10-septate, 5–25 × 4–9 µm.

Gliophragma setosum Subram. & Lodha, Can. J. Bot. 42: 1060. 1964. Fig. 5

Conidial fungi, hyphomycetes. Colonies on natural substrate effuse, cottony, grayish, velvety. Mycelium party superficial on the substrate, composed of septate, branched, hyaline, smooth hyphae 2–2.5 µm wide. Synnemata erect, straight to flexuous, brown, 105–150 × 12–25 µm, enclosing the lower part of setae. Setae branched, septate, smooth, light brown, 230–270 × 2.5–4 µm; middle seta unbranched, dark brown, thick-walled, 260–300 × 3–6.5 µm. Conidiophores macronematous, synnematous, septate, branched, light brown, smooth, 170–250 × 3–5 µm, developing together with setae. Conidiogenous cells polyblastic, integrated. Conidia aggregated in slimy, light brown masses; individual conidium hyaline, smooth, consisting of 5–7 cells separated by narrow isthmi, 40–48.5 µm long, 3–4.5 µm wide.

SPECIMEN EXAMINED: On leaf litter, 04/11/2006, J. Pratibha, Mahabaleshwar, Maharashtra, India, Herb. No. HCIO 48135; GUBH MH12.

NOTES: *Gliophragma setosum* originally isolated from horse dung from Massoorie, Uttar Pradesh, India, is the type and only species of the genus *Gliophragma* Subram. & Lodha (Subramanian & Lodha 1964). We isolated the fungus from plant litter collected at Mahableshwar, India, and this is only the second known collection.

Acknowledgments

We thank the University Grants Commission, Council of Scientific and Industrial Research and Ministry of Environment & Forests, Government of India, New Delhi, for financial support in the form of research grants during the tenure of which this work was carried out. The authors thank Prof. Bryce Kendrick, Canada, and Dr. Eric McKenzie, New Zealand, for reviewing the manuscript.

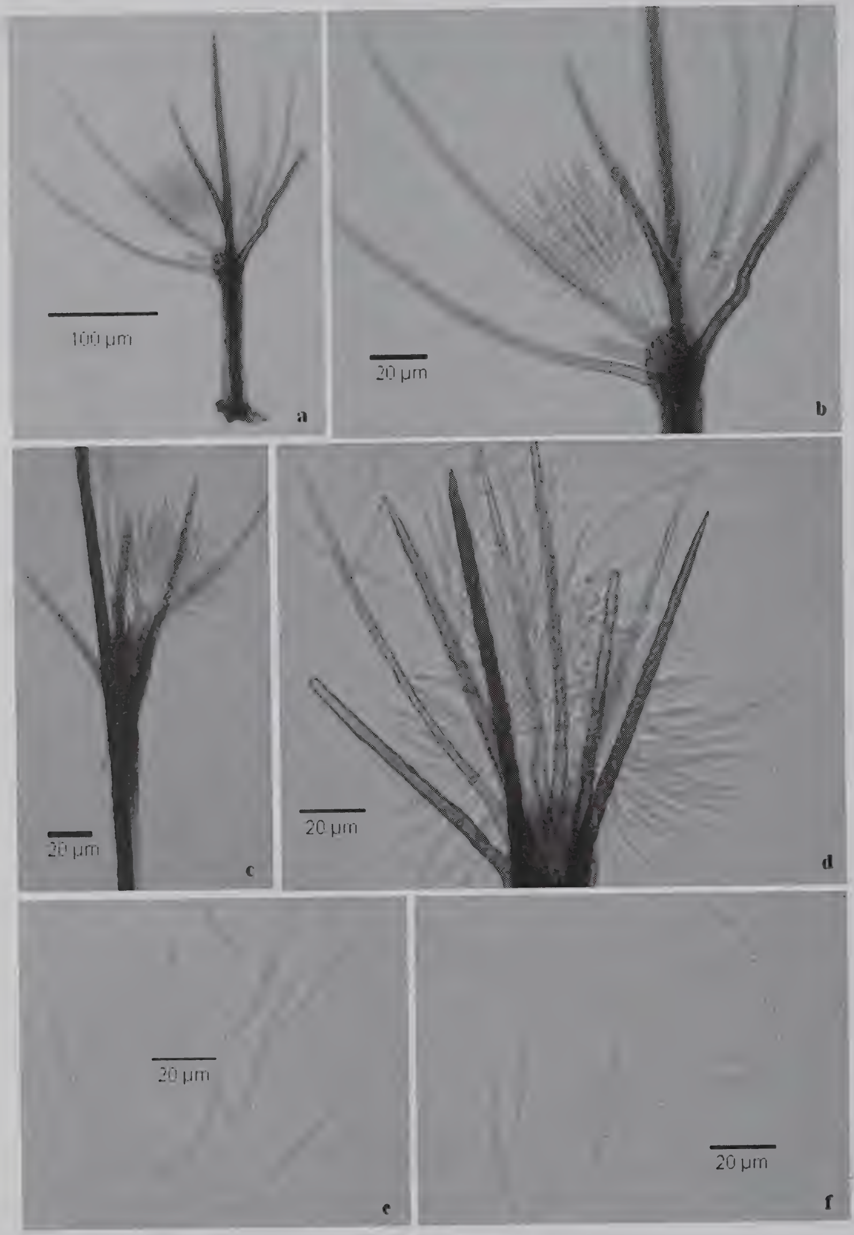
100 µm
a
20 µm
b
20 µm
c
20 µm
d
20 µm
e
20 µm
f

Fig. 5. ***Gliophragma setosum.***
a. Setose synnema; b–d. Conidiogenous cells with conidia;
e–f. Conidia with isthmi.

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MYCOTAXON

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Record of the rare greenhouse fungus *Lepiota elaiophylla* (*Agaricales, Agaricaceae*) in Prague, Czech Republic, with notes on its taxonomy and distribution

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Abstract — A find in Prague (Praha) of *Lepiota elaiophylla*, a recently described species growing in greenhouses and containing amanitins, is published. The fungus was found on soil in a large flower pot with a horticultural variety of *Guzmania* sp. (*Bromeliaceae*), bought in a flower shop in Prague and later kept in a heated room of a rectory. Macro- and microcharacters are presented and discussed and the substrate and habitat are described in detail. The world distribution is summarized. To date, *L. elaiophylla* is known from 6 countries of western, central and southern Europe and from natural habitats in the Neotropics of Brazil.

Key words — *Basidiomycota*, systematics, mycogeography, Central Europe

Introduction

Lepiota elaiophylla was described as a new species quite recently (Vellinga & Huijser 1998). It was distinguished from its counterpart *Lepiota xanthophylla* P.D. Orton by structure of the pileus covering, shape of the cheilocystidia and colours of the basidiocarps (Vellinga & Huijser 1998, Vellinga 2001a). In the protologue, collections from the Netherlands were cited. Moreover, several records from Europe published as *L. xanthophylla* are considered to be in fact *L. elaiophylla* (Vellinga & Huijser 1998). They originate from Germany (Besl et al. 1984), Italy (Migliozzi et al. 1989) and Switzerland (Breitenbach & Kränzlin 1995: no. 236). Recently, *L. elaiophylla* was found in Austria, in the tropical greenhouse of the Botanical Garden in Graz and in a glasshouse of the Botanical Garden in Vienna (Pidlich-Aigner & Hausknecht 2001, Pidlich-Aigner et al. 2002) and in a tropical greenhouse of a butterfly farm in Mecklenburg-Vorpommern, Germany (Kreisel 2007). In all these countries, *L. elaiophylla* was found exclusively in greenhouses or hothouses whereas *L. xanthophylla* grows in deciduous forests in temperate Europe (Vellinga & Huijser 1998). Concerning the occurrence of *L. elaiophylla* in the wild, Vellinga & Huijser (1998) discuss a record by Pegler (1977) from east Africa; however, there are some discrepancies in several microcharacters. Records from natural habitats in Brazil were published by Meijer (2006: state of Paraná) and Wartchow et al. (2008: state of Pernambuco).

As shown by Besl et al. (1984), *L. elaiophylla* (misidentified as *L. xanthophylla*, see Vellinga & Huijser 1998) contains α-amanitin and β-amanitin.

Phylogenetic analysis of *Lepiota* (Vellinga 2001b, 2003) showed that *L. elaiophylla* belongs to a different clade than *L. xanthophylla* and that this clade also harbours other amanitin containing species like *L. subincarnata* J.E. Lange and *L. brunneoincarnata* Chodat & C. Martín.

The aim of this paper is to describe macro- and microcharacters of the Prague record of *L. elaiophylla* and to summarize the recent information on its taxonomy and distribution.

Material and methods

All microscopic examinations were made using an Olympus BH-2 microscope. The observations and measurements were made on material mounted in a 5% KOH solution. Iodine reaction was studied in Melzer's reagent prepared according to the formula given in Moser (1983). For spore size measurements, randomly selected mature spores were used. Spores were measured without the hilar appendix (apiculus). The expression [41,2,1] means that 41 spores from 2 basidiocarps originating from 1 collection were measured. Illustrations of microcharacters were drawn at a magnification of 1250 × using a drawing tube. For micromorphological terminology see Bas et al. (1988). The collection studied is kept at the Mycological Department of the National Museum, Prague, Czech Republic (herbarium PRM).

Results

Lepiota elaiophylla Vellinga & Huijser PLATE 1

Bollettino del Gruppo Micologico G. Bresadola – Nuova Serie 40(2–3): 462, 1998 ("1997").

MACROCHARACTERS (of slightly dried-up fruitbodies brought to National Museum, Prague, by the second author) — PILEUS 5–23 mm, hemisphaerical with involute margin when young, then convex, dry, brown tomentose when young, then disrupting into densely arranged, adpressed, tomentose, up to 1 mm broad ochre-brown, olive-brown to brown scales on lemon-yellow background; LAMELLAE medium dense, L = 40–50, l = 1, ventricose, lemon yellow, lamellar edge irregular, concolorous; STIPE 20–45 × 2–4 mm, cylindrical, hollow, without ring, with lemon-coloured arachnoid veil when young, which disappears with age, upper quarter to third glabrous, pale lemon-yellow, towards base with concolorous background but covered with densely arranged scales having the same character as those on pileus surface; CONTEXT pale lemon-yellow in pileus, whitish with lemon tinge in stipe; SMELL musty, like a cellar; TASTE mild.

MICROCHARACTERS — BASIDIOSPORES (6.5)6.8–8.0(8.5) × (3.2)3.5–4.0 µm [41,2,1], mean value 7.2 × 3.6 µm, Q = 1.70–2.22, average 2.00, in face view oblong to subcylindrical, in side view with slight suprahilar depression, with short hilar appendix, slightly thick-walled, smooth, hyaline in water or KOH, distinctly dextrinoid in Melzer's reagent (wall yellow-brown, interior pale brown-violet); BASIDIA 22–32 × 7–8 µm (without sterigmata), clavate, 4-spored; BASIDIOLAE 17–25 × 5–8 µm, clavate; LAMELLAE EDGE almost sterile, rarely with basidia; CHEILOCYSTIDIA numerous, 1- to 3-celled (with 0–2 basal cells which are short and cylindrical), terminal cells 17–30 × 5–10 µm, narrowly clavate to clavate, thin-walled, hyaline; PLEUROCYSTIDIA absent; LAMELLAR TRAMA regular to subregular, composed of parallel to subparallel hyphae 2–10(12) µm broad, cells cylindrical and long or slightly inflated and short (15–40 µm), hyaline, with yellow membranal pigment, subhymenium made up of densely arranged, short, branched, septate cells; PILEUS CUTICLE a thick intricate trichoderm, composed of long, interwoven, flexuous hyphae mostly composed of 1–3 cells, basal cells short, cylindrical or inflated, flexuous, terminal cells long, 50–150 × 9–13 µm, flexuose, cylindrical, narrowly fusiform or narrowly clavate, slightly thick-walled, with up to 0.5 µm thick wall, with homogeneous yellow membranal pigmentation; PARTIAL VEIL (looking like cortina between pileus margin and upper part of stipe) composed of parallel to slightly interwoven hyphae, 3–6 µm broad, cylindrical, thin-walled, finely yellow-brown incrusted; SCALES on stipe surface composed of cells resembling those on pileus surface, terminal cells long, interwoven, flexuous, cylindrical or narrowly clavate, slightly thick-walled, with up to 0.5 µm thick wall, basal cells shorter and narrower, cylindrical; CLAMP CONNECTIONS present in all tissues.

HABITAT — *L. elaiophylla* was found on soil in a large flower pot with a horticultural variety of *Guzmania* sp. (*Bromeliaceae*) in the year 2007. The flower pot with the plant was bought in about 1997 in a flower shop in Prague, Lazarská street. The origin of the plant and of its substrate (soil bought in a flower shop) is unknown. In about 2003, the *Guzmania* was replanted into a larger flower pot with garden substrate of unknown origin. Till 2006, the flower pot was kept in a private house in a room where it was hot in summer (25–35 °C) and without heating in winter (average temperatures about 15 °C). During this period the fungus was not observed. In 2007, the flower pot was moved to the rectory in Prague-Holešovice and kept in a heated room with rather stable

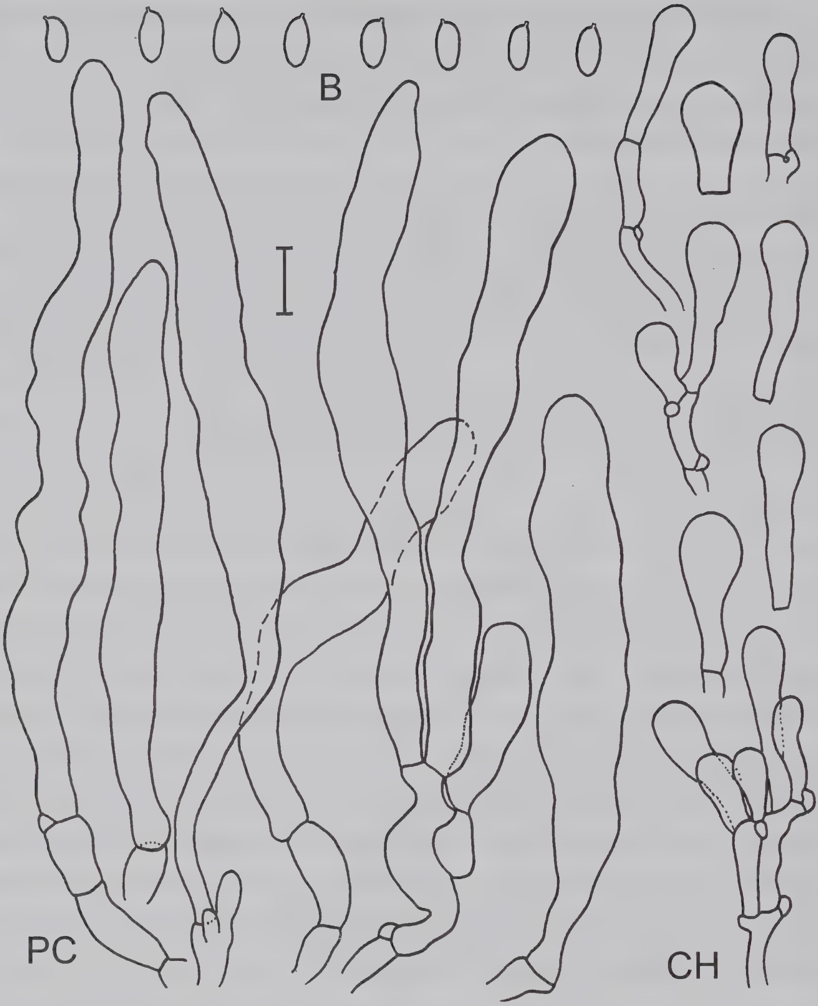

Plate 1. Microcharacters of Lepiota elaiophylla (PRM 858090).
B: basidiospores, CH: cheilocystidia, PC: pileus cuticle. Bar = 10 µm.

average temperature (about 23 °C). However, the fructification of *L. elaiophylla* was observed on hot August days when the temperature was higher (up to 30 °C). During the whole period 1997–2007, *Guzmania* was normally watered (no special treatment).

Material studied — **CZECH REPUBLIC. Prague (Praha)**, city part Prague-Holešovice, street Dukelských hrdinů 54, rectory of the church of sv. Antonín (St. Anthony), on soil in large flower-pot inside a room, 16.VIII.2007 leg. Matúš Kocian, det. J. Holec, rev. E. C. Vellinga (PRM 858090).

Discussion

Taxonomy

Basidiocarps of *L. elaiophylla* found in Prague agree in all important characters with the original material from the Netherlands described by Vellinga & Huijser (1998). The conspecificity was also confirmed by E.C. Vellinga who obtained the material for revision. The pileus colour given in the original description is more vivid (dark orange-brown or reddish-ochraceous brown at centre). However, the colours of Prague basidiocarps were observed in slightly dry state one day after the removal of the basidiocarps from the flower-pot when the colours were not so bright anymore. Mean values of spore size of Prague material are slightly smaller than in the original description but they are within the range given by Vellinga & Huijser (1998). Except for these small differences, all diagnostic characters of *L. elaiophylla* (characters of the similar species *L. xanthophylla* P. D. Orton are given in brackets) are present: absence of a distinct layer of clavate elements in pileus cuticle (present in *L. xanthophylla*), clavate cheilocystidia (lageniform, utriform to clavate in *L. xanthophylla*), slightly smaller spores (up to 10 × 5 µm in *L. xanthophylla*), olive to lemon-yellow tinge on pileus surface (yellow in *L. xanthophylla*) and dirty olive-brown colour of dry lamellae (yellow in *L. xanthophylla*). The same characters were also observed by Pidlich-Aigner & Hausknecht (2001).

Distribution and ecology

To date, *Lepiota elaiophylla* is known only from 6 countries of western, central and southern Europe (The Netherlands, Germany, Switzerland, Austria, Czech Republic, and Italy; for references see Introduction) and from Brazil (Meijer 2006, Wartchow et al. 2008). *L. elaiophylla* is included in the red list of Finnish fungi (Rassi et al. 2001) in the category of not evaluated taxa and without any information on its record in this country. According to Hansen & Knudsen (1992), the species is not known from Nordic countries, which was confirmed by J. Vesterholt, the editor of a new edition of Nordic mycological flora (pers. comm., 2008).

The identity of a potential record from east Africa (Pegler 1977, as *L. xanthophylla*) is uncertain (Vellinga & Huijser 1998). The record by Saar (2001) from Germany needs a revision (if a voucher specimen exists) as the published photograph suggests that the fungus could be *L. xanthophylla*. All European records originate from greenhouses, hothouses (often in botanical gardens) or rooms and the fungus was found on horticultural substrate used for cultivated plants. It is apparent that the fungus requires relatively high temperature for its fructification. This agrees well with its records from natural habitats in the Neotropics of Brazil. In the state of Paraná, the fungus was found in a mixed ombrophilous forest and dense ombrophilous forest at an altitude up to 900 m (Meijer 2006), in the state of Pernambuco it was growing solitary on soil among litter in a tropical forest (Wartchow et al. 2008). The species appears to be widespread, as Pernambuco and Paraná are quite far away from each other.

Concerning the European records, it would be interesting to know whether the fungus is distributed via mycelium in horticultural substrate of tropical or subtropical origin (or in substrate of other tropical plants moved from nature to the greenhouses) or via air transport of spores. At this moment it is impossible to solve this question as in all published records the origin of its substrate is unknown. It is also interesting to know how long the spores are viable, and how long it takes for the mycelium to produce fruitbodies.

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Morchella tomentosa, a new species from western North America, and notes on *M. rufobrunnea*

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Abstract — A new species of *Morchella, M. tomentosa*, is described from western North America; the range of *M. rufobrunnea*, previously documented from Mexico's Gulf Coast, is extended to California and Oregon; the history of taxonomic names applied to *M. rufobrunnea* on the West Coast is discussed.

Key words — morels, taxonomy

Introduction

Over 500 North American collections of *Morchella* were solicited from amateur collectors or made by the author from 2002 to 2007 as part of an effort known as the Morel Data Collection Project (MDCP). Preliminary molecular results (see Kuo 2005, 2006) revealed over a dozen genetically distinct morels among the collections. While several of these putative species are morphologically cryptic, as yet poorly documented, or otherwise insufficiently understood, two morels from western North America are easily distinguished morphologically and ecologically. One is *M. rufobrunnea*; the other, *M. tomentosa*, has been informally described (Kuo 2005, 2006, McFarlane et al. 2005, Pilz et al. 2004, 2007) but not previously given formal taxonomic status.

Taxonomy

Morchella tomentosa M. Kuo, **sp. nov.** PLATE 1

MycoBank MB 511840

Ascomata (40)50–120 mm alta; capitulum subconicum vel subcylindricum vel ovoideum; costae tomentosae, canae vel atrae, interdum pallescens; hymenium atrum, interdum pallescens; stipes tomentosus, ater, interdum pallescens; pili 100–400 × 7–28 µm; bruni in 2% KOH.

Holotypus. *Biotopium in silvis coniferibus incensis; 1,200 m. altitudinis; USA, in Montanaense, ad Mineral County; S. Engstrom col.; MDCP 06150405; specimen typicum in Herb. F. conservatum.*

Ascomata (40)50–120 mm high. Hymenophore (20)30–110 mm high; (15)30–50 mm wide at the widest point; subconic to subcylindric or ovoid; pitted and ridged; with 18–26 primary vertical ridges and numerous shorter, secondary vertical ridges and transecting horizontal ridges; attached to stipe with a sinus about 1–2 mm deep and 1–2 mm wide. Ridges densely tomentose; black, silvery black, brownish black, brownish gray, watery gray, brown, or brownish when young; becoming gray, grayish, pale tan, or whitish with maturity; bluntly rounded when young, but with age often flattened or eroded, revealing the whitish context beneath. Pits primarily vertically elongated by maturity but irregularly shaped when young; glabrous; opening and deepening with development; progressing from gray or nearly black when immature to gray, watery gray, brown, yellowish tan, or nearly white (especially when exposed to prolonged sunlight) at maturity. Stipe 20–60 mm high; 10–40 mm wide; often basally clavate to subclavate; flared slightly to apex; densely tomentose and gray to black when young, becoming finely tomentose or nearly glabrous and gray to tan, watery brownish, or nearly white, with brownish tufts of separated tomentum. Context whitish; 1–5 mm thick in the hollow hymenophore; in the stipe chambered or layered. Sterile inner surface whitish and pubescent.

Chemical reactions (tested on MDCP 08070404, two days after collection): Ammonia very pale orange, then grayish on sterile inner surface and context, negative on hymenium; KOH (5%) negative on all surfaces; FeSO4 negative on all surfaces.

Ascospores elliptical; smooth; contents homogeneous; (15)18–20(22.5) × (7.5)8–12.5(15) µm; average Q=1.87. ASCI 8-spored; 225–290 × 12.5–20 µm; cylindric; hyaline. Paraphyses cylindric to subclavate; apices rounded to subacute; with 2-5 septa; hyaline or with brown to brownish homogeneous contents in KOH (2%); (125)150–175(225) × 5–10(15) µm. Residual paraphyses on sterile ridges similar to paraphyses; hyaline or with brownish contents; bundled. Hairs on sterile ridges projecting from residual paraphyses; variable in shape (cylindric, clavate, subclavate, lageniform, or subcapitate); 120–250(400) × 7.5–15(25) µm; abundant; with brown to brownish contents in KOH (2%); septate; often with thickened walls. Hairs on stipe surface abundant; cylindric to subclavate; septate; 100–275 × 10–17 µm; with brown walls in KOH (2%); contents hyaline to brownish.

Ecology — Appearing at altitudes of 1,000–3,400 m in lightly to moderately burned conifer forests including forests dominated by *Pseudotsuga menziesii* (Mirb.) Franco on the West Coast and forests dominated by *Picea engelmannii* Parry and *Abies lasiocarpa* (Hook.) Nutt. or *Pinus contorta* var. *latifolia* Engelm. in the Rocky Mountains. Found primarily in years following forest fires but

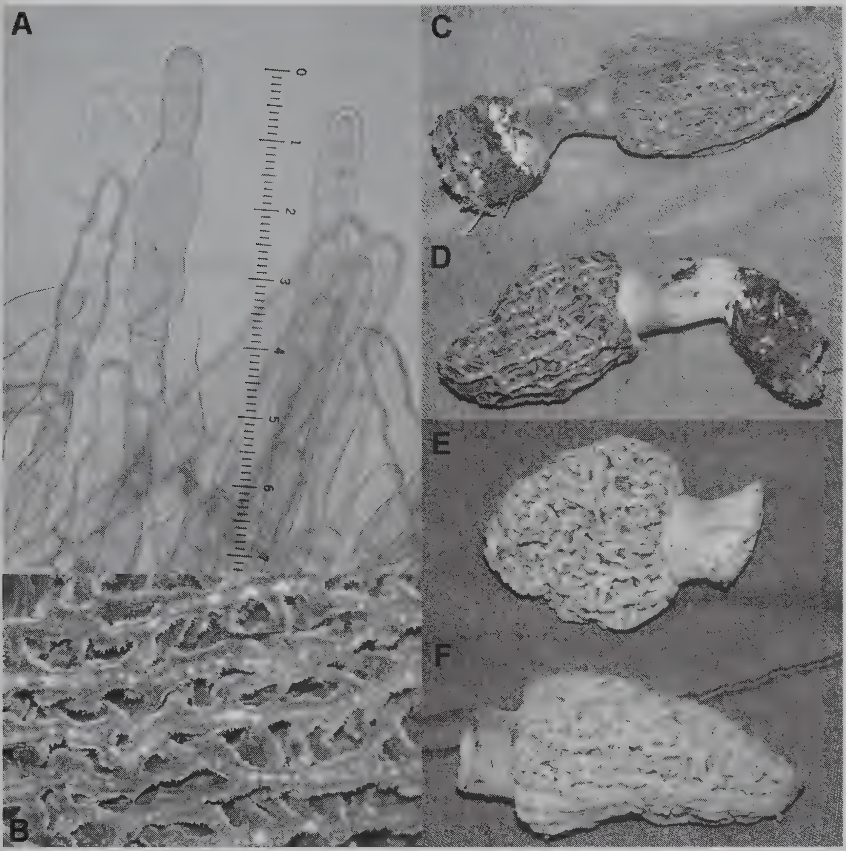

Plate 1. *Morchella tomentosa.* A: Pigmented hairs on stipe surface (scale: × 2.5 µm). B: Tomentose ridges of young hymenophore. C: Holotype specimen (about half life size). D, E, F: Isotype specimens (about half life size), demonstrating morphological variability.

often appearing in dwindling numbers for several seasons thereafter; Alaska, the Yukon Territories, Montana, Idaho, Oregon, and Colorado; May through August.

Specimens examined — **UNITED STATES OF AMERICA:** MONTANA—05300402 (May 30, 2004; Ravalli County, S. Schwartzman); 06100102 (June 10, 2001; Ravalli County, J. Holmes); 06150402, 06150403, 06150405 HOLOTYPE, 06150406, 06150407, 06150409 (June 15, 2004; Mineral County, S. Engstrom); 06170402 (June 17, 2004; Missoula County, S. Engstrom); 06180401, 06180402, 06180403, 06180404, 06180405, 06180406, 06180407, 06180408, 06180409, 06180413, 06180414, 06180415, 06180420, 06180421 (June 18, 2004; Mineral County, S. Engstrom); 06300401, 06300402, 06300403, 06300404, 06300406, 06300408 (June 30, 2004; Missoula County, S. Engstrom); 07010401, 07010402, 07010403, 07010404 (July 1, 2004; Missoula County, S. Engstrom); 07070402, 07070403, 07070407 (July 7, 2004; Missoula County, S. Engstrom); 07130401, 07130406, 07130407, 07130408, 07130409 (July 13, 2004; Missoula County, S. Engstrom); 07140401, 07140402, 07140403 (July 14, 2003; Missoula County, S. Engstrom). IDAHO—06040401 (June 4, 2004; Valley County, K. Greger); 06180423 (June 18, 2004; Valley County, K. Greger); 06190401 (June 19, 2004; Valley County, K. Greger). OREGON—04070402 (April 7, 2004; Lane County, M. Sheller); 08070404 (August 7, 2004; Jefferson County, M.C. Carter). COLORADO—08310301 (August 31, 2003; La Plata County, G. Fitzgerald). Accession numbers are from the Morel Data Collection Project. All collections are housed in the Mycology Collection of the Field Museum of Natural History (F), Chicago.

COMMENTS — The densely tomentose (and frequently black) surfaces of young specimens of *Morchella tomentosa* separate it easily from other species of *Morchella*—though older specimens (especially those that have been exposed to prolonged sunlight) may have eroded ridges and paler colors that approximate the colors of *M. esculenta*-like yellow morels, leading to confusion. However, pale and less tomentose specimens still demonstrate pigmented hairs on the sterile ridges and stipe surface and can thus be separated microscopically. *Morchella tomentosa* is known as the "gray morel" by commercial collectors in western North America; eastern and Midwestern collectors, however, use the same term for immature forms of *M. esculenta*-like yellow morels.

In North America *Morchella tomentosa* has been described by Pilz et al. (2004) as "PS D" (putative species D); by Kuo (2005) as the "black foot morel"; by Kuo (2006) as the "fuzzy foot morel"; and by Pilz et al. (2007) as the "gray morel." Additionally, the name *M. atrotomentosa* has been applied (McKnight & McKnight 1987) to a western North American burn-site morel that arguably meets the description of *M. tomentosa*. However, *M. atrotomentosa* is an invalid taxon (McFarlane et al. 2005, Pilz et al. 2007): the basionym was originally published by Moser (1949) as a temporary (ad interim) taxon. No type collection was designated for Moser's "*Morchella esculenta* (L.) var. ***atrotomentosa*** nov. var. ad. [sic] int.", which Moser (1949) documented fairly rigorously as a burn-site morel from the Alps that shares many of the morphological features emphasized for the present species—including the dark, tomentose hymenophore and stipe and the pigmented hairs. Thus the epithet *tomentosa* is chosen in part to reflect potential continuity with Moser's invalid taxon while also acknowledging that the North American species, while always tomentose, is not always black-tomentose. Moser described only a black to blackish brown hymenophore and stipe.

Jacquetant (1984) described and illustrated "*Morchella atrotomentosa* (Moser) Bride." While the watercolor illustrates a species similar to *M. tomentosa*, the description is inadequate for thorough comparison, and Jacquetant does not document any material examined. Further, no reference is provided for the Bride authority. Attempts to locate a publication by Bride, or a citation for a publication by Bride, have been unsuccessful. Moreover, the combination "*M.*

atrotomentosa (Moser) Bride" is built on an invalid basionym. Validation of Moser's name would have required a proposal to conserve —a conspicuous maneuver that would be easily discovered in standard taxonomic references.

Morchella rufobrunnea in California and Oregon

Morphological analysis and preliminary molecular results (see Kuo 2005, 2006) indicate that the winter-fruiting yellow morel from West-Coast landscaping sites is *Morchella rufobrunnea* Guzmán & F. Tapia. This species is quite distinct and well characterized by its ecology, its abruptly conical young cap with pale ridges and nearly black pits, and its rufescence.

Guzmán & Tapia (1998) described *Morchella rufobrunnea* based on Mexican collections from Xalapa, Veracruz, on Mexico's Gulf Coast, made along a roadbed and in a garden. Collections from landscaping and similar disturbed-ground sites in California and Oregon matching the *M. rufobrunnea* isotype (MDCP 06059601) have been studied (see Specimens Examined, below). All specimens demonstrate a morphology consistent with the original description of the species.

Since *Morchella rufobrunnea* is so visually distinct it can often be recognized in photographs; the species appears to have been described as "*M. deliciosa*" and as "*M. esculenta*" by western North American authors. Arora (1986) depicts a "coastal Californian form of *Morchella deliciosa*" growing "in gardens and other suburban habitats" that appears to match *M. rufobrunnea*. Photographs of California collections of "*M. deliciosa*" in Wood & Stevens (2007) also match *M. rufobrunnea*; the authors describe a mushroom occurring "in bark/wood chips of fresh landscaping or in disturbed locations, e.g. near compost heaps, fire pits, dirt basements, logging roads etc." Additionally, photographs of "*M. esculenta*" in Ower (1982) suggest that the species cultivated by Ower (and, later, others) was *M. rufobrunnea*. I have examined cultivated morels from Diversified Natural Products (MDCP 03110601, produced in Michigan) that also match *M. rufobrunnea*, and represent an original California collection (G. Mills, pers. comm.)

Specimens examined — **MEXICO:** VERACRUZ—06059601 (June 5, 1996; Xalapa, G. Guzmán; ISOTYPE). **UNITED STATES OF AMERICA:** CALIFORNIA—03180301 (March 18, 2003; Solano County, W. Andrew); 03300302 (March 30, 2003; Sacramento County, D. Kimberling); 03180401 (March 18, 2004; Ventura County, R. Sharman); 12110401 (December 11, 2004; San Diego County, C. Nielsen); 03060501 (March 6, 2005; Santa Clara County, M. Munch); 03270501 (March 27, 2005; Siskiyou County, J. Plischke); 03290501 (March 29, 2005; Tulare County, J. Plischke). OREGON—03080501 (March 8, 2005; Jackson County, J. Petersen). MICHIGAN—03110601 (March 11, 2006; produced in Mason County, M. Kuo). Accession numbers are from the Morel Data Collection Project. All collections are housed in the Mycology Collection of the Field Museum of Natural History (F), Chicago.

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The author thanks Carol Carter for many years of patient help in understanding morels, Gastón Guzmán for providing isotype material, Kerry O'Donnell, Carol Schmudde, Ron Petersen, Fred Kränzlin, Harald Kellner, Gary Mills, Sue Yokum, Robert Lücking, Kate Klipp, and Stephen Canfield. Presubmission reviews were kindly provided by Tom Volk, Rodham Tulloss, Patrick Leacock, and Andrew Methven. The author also thanks the following individuals for the kind donation of specimens cited in this paper: William Andrew, Carol Carter, Scott Engstrom, Gretchen Fitzgerald, Ken Greger, John Holmes, Dan Kimberling, Mary Munch, Carl Nielsen, Jamie Petersen, John Plischke III, Steve Schwartzman, Robert Sharman, and Mike Sheller.

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Ganoderma vivianimercedianum sp. nov. and the related species, *G. perzonatum*

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Abstract — A new species of *Ganoderma*, *G. vivianimercedianum* is described from Cuba, Brazil and Mexico. It is distinguished by its flabelliform basidioma with a contracted base and a conchate, radially rugose pileus with claviform and granulated cuticle cells and context that is not completely homogeneous. Comparisons with related species and a full description of *G. perzonatum* are also provided.

Key words — *Ganoderma argillaceum, G. resinaceum*

Introduction

In the course of the study of *Ganoderma* developed by the first author, two specimens deposited in NY, both marked as representing the type of *G. argillaceum* Murrill, were examined. However, these two specimens differ in several features, raising questions both about their conspecificity and the species concept of *G. argillaceum*. Moncalvo & Ryvarden (1997) cite the usually accepted type of *G. argillaceum*, NY collection F.S. Earle 658 (5 July 1904), which corresponds to the characteristics described in the protologue and is the only specimen mentioned by Murrill (1908). The other specimen appears more closely related to *G. perzonatum* and *G. resinaceum* Boud. The types or authentic material of *G. perzonatum* and *G. resinaceum* were compared with the material in question.

As a result of these type studies, we propose and describe a new species based on the second collection previously referred to *G. argillaceum* and additional specimens from Brazil and Mexico. We also provide an updated description of *G. perzonatum*.

Materials and methods

Materials studied are deposited at BPI, ENCB, IBUG, NY and SP. The colors are based in Kornerup & Wanscher (1963). Micromorphological observations were made from basidiome tissues mounted in 5% KOH and Melzer's reagent. Basidiospore shape is based on the Q coefficient (length-width, Bas 1969) of 20 randomly selected spores.

Taxonomy

Ganoderma vivianimercedianum Torres-Torres, **sp. nov.** Figs. 1-10

MycoBank MB511309

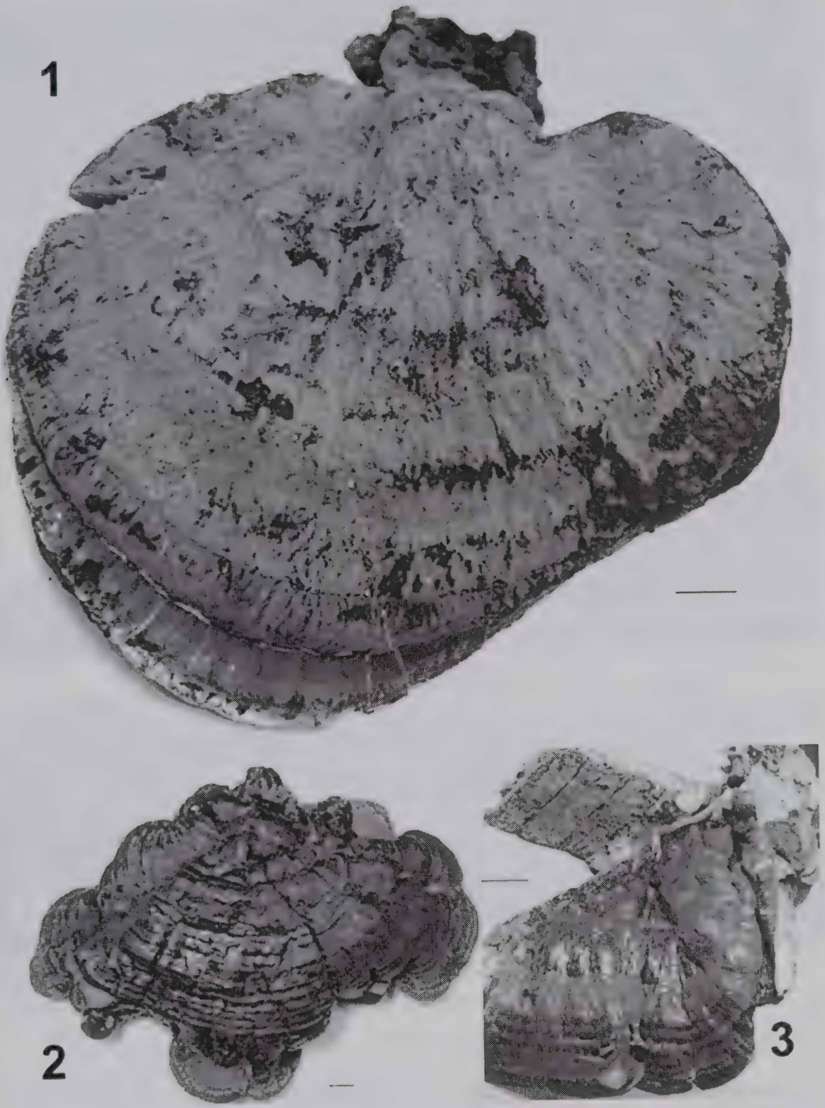
Fructificatio lignicola, perenne, sessilia vel substipitata; superficies demum rubro-brunnea, crustosa vel laccata; pori 3-5 per mm; contextus pallido-bubalinus vel purpureo-brunneus, non zonae resinosa; systema hypharum trimiticum; hyphae generatoriae fibulatae; hyphae skeletales nonseptatae, arboriformes; cutis hymeniodermiformis, pallide brunneae, dextrinoidea, elementis entire vel lobata, 36-72 × 7.2-13.6 µm; basidiosporae ellipsoideae, truncate, luteo-brunnea, paries duplexis, cum columnae interparietis, 9.6-11.2 × 6.4-8 µm.

MEXICO, Estado de México, Valle del Tepeite, 10 km NE of Santa Maria, 10 August 1986, E. Bastidas-Varela s.n (**Holotype**: ENCB).

Etymology: In memory of Angie Viviana and Rosa Mercedes, niece and aunt of the first author.

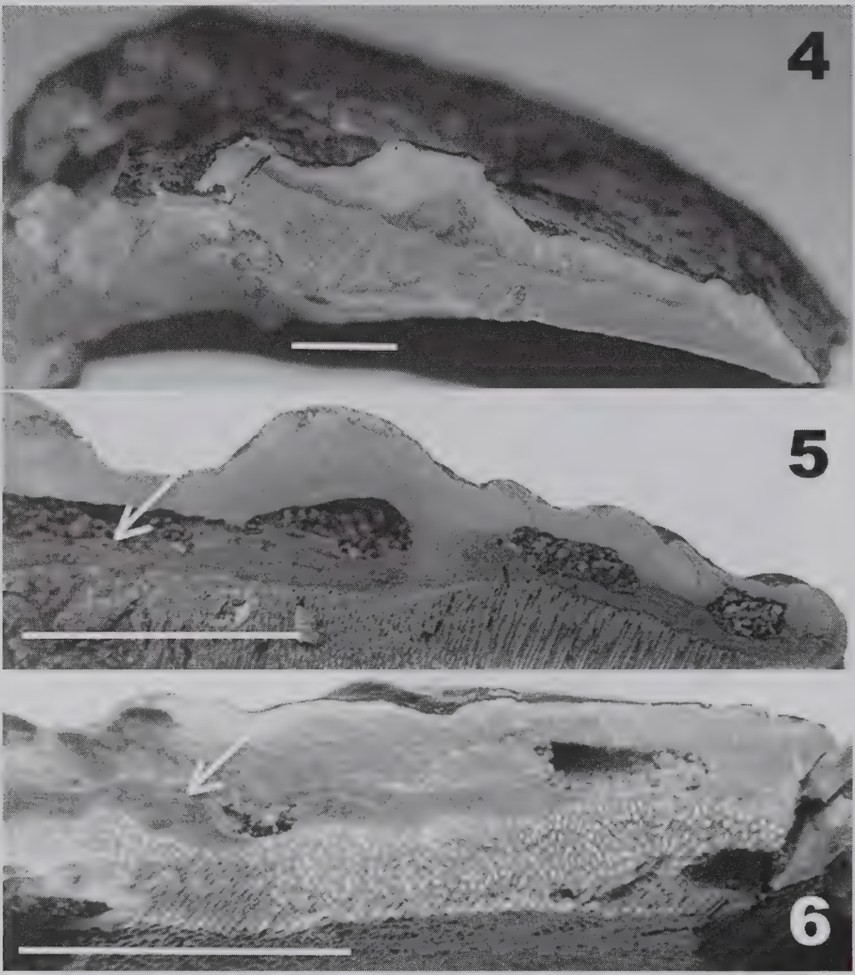
Basidiomata 6.5-10 × 8.5-13 × 1.3-1.5 cm, annual, sessile to substipitate, then with a contracted base, single, woody-corky consistency, light in weight. Pileus flabelliform, conchate; surface glabrous, bumpy, concentrically sulcate, radially rugose, glossy; with a laccate crust, not cracking, difficult to remove, easy to penetrate with fingernail; violet-brown (11F7-11F8) in the 80 to 90% of the surface, to henna (7E8-8E8) in the periphery; margin whitish to yellowish, generally entire to slightly lobulate, thin, smooth. Substipe 2 × 1.3 cm, lateral, cylindrical, solid, surface shiny, darker than pileus, red-wine to almost black. Context 0.9-1.3 cm thick, 0.6 cm average, fibrous-corky, zonate, not completely homogeneous, caramel (6C6) above to dark brown (7F7) toward the tubes; with resinous incrustations (not observed in the type). Pores 3-5 per mm, angular to circular, woody; pore surface pastel-yellow (2A4), darkening to brown (6D8) when bruising or aging; tubes 0.5-0.9 cm thick, up to 1.2 cm in the base, unstratified, concolorous with the inferior part of the context.

Hyphal system trimitic. Contextual trama with generative hyphae 1.8-4.8 µm diam, hyaline, branched; skeletal hyphae 3.2-12.4 µm diam., generally



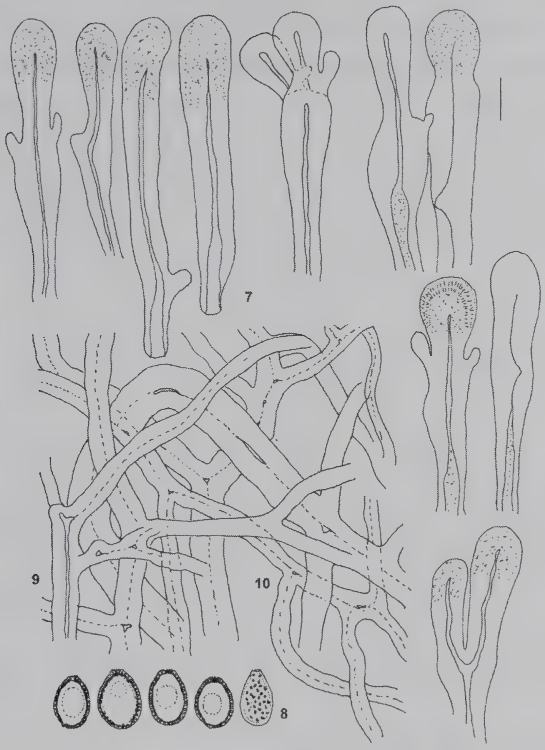
Figs. 1-3. *Ganoderma vivianimercedianum* basidiomata.
1: holotype., 2: Pacheco s.n., 3: Sotao et al. 88.21.26. Scale bar = 1 cm.

solid to thick-walled, non-septate, arboriform, yellowish to golden-yellow, predominant; binding hyphae 1.9-8.8 µm diam., solid, non-septate, yellowish to light yellowish-brown. Hymenophoral trama as contextual trama. Pileipellis with cuticle cells 36-65 × 7.2-12 µm, narrowly claviform to clavate,



Figs. 4-6. *Ganoderma vivianimercedianum* basidiomata showing context that is not completely homogeneous. Arrows indicate resinous incrustations. 4: Earle s.n., 5: Pacheco s.n., 6: Sotao et al. 88.21.26. Scale bar = 1 cm.

entire or with up to two lateral protuberances, not branched or few with two apical branches; thick-walled, unstratified, golden-yellow, with granulations in the apex; cells dextrinoid in Melzer's reagent. Basidiospores 8.8-11.2(-12) × 6.4-8 μm, Q = 1.25-1.5, ellipsoid, apex truncate, light yellowish-brown, negative in Melzer's reagent; perisporium wrinkled, hyaline; exosporium with inter-walled pillars up to 0.3 μm thick, subfree; endosporium wrinkled, with apical germ pore. Basidiospores print rust-brown (6E8) (from the deposit of spores on the pileus). Basidia not seen. Cystidia absent.



Figs. 7-10. Microscopy of *Ganoderma vivianimercedianum* (Earle s.n).
7: Cuticle cells, 8: basidiospores, 9: binding hyphae, 10: skeletal hyphae.
Scale bar = 8 μm.

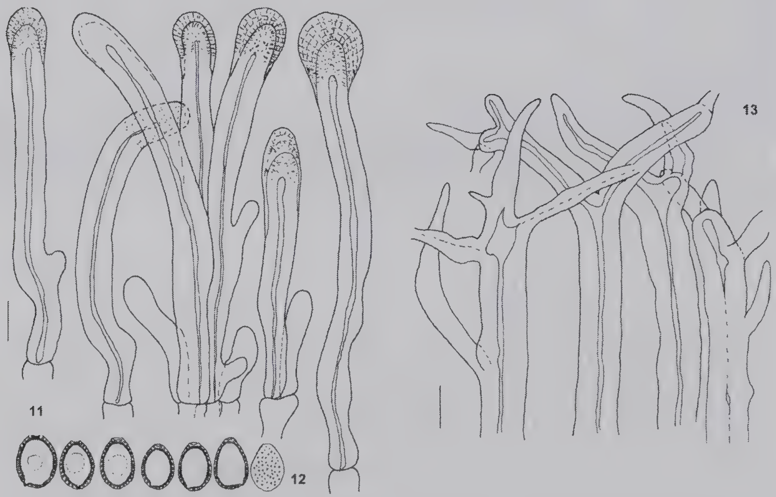
SUBSTRATA – Dead wood.

HABITAT – Secondary tropical forest, mangrove.

SPECIMENS STUDIED - **CUBA**, sine data (NY). **BRAZIL**, Guaiba, Rio Grande do Sul, Fazenda da Faculdade de Agronomia e Veterinária, em lenho morto, 29 March 1963, J.P. de Costa-Neto s.n. (SP70533); São Paulo, Tremembé da Cantareira, Villa Amalia, Horto Forestal SPSF, podridao da madeira, 20 May 1952, C.D.F. Pacheco s.n. (SP109563); Amapá, Ilha de Maracá, tronco de madeira en descomposição, 24 October 1988, H. Sotao et al. 88.21.26 (SP233297). **MEXICO**, Estado de México, Valle del Tepeite, 10 km NE of Santa Maria, 10 August 1986, E. Bastidas-Varela s.n. (holotype, ENCB); Jalisco, Zapopan, Centro Universitario de Ciencias Biológicas y Agropecuarias, Departamento de Madera Celulosa y Papel, on dead wood, 21 October 2006, M.G. Torres-Torres 699 (IBUG); Veracruz, 5 km from Jaltipan, on dead wood, 19 March 1978, J. Pérez-Ortiz 1278 (ENCB).

Ganoderma perzonatum Murrill, North Amer. Flora 9: 121, 1908. Figs. 11-13

Basidiomata 2:5-8.5 × 4.8 × 0.7-1.5 cm, annual or perennial, substipitate, single to imbricate, woody-corky consistency, light in weight. Pileus flabelliform; surface glabrous, bumpy, glossy, concentrically sulcate; with a laccate crust, not cracking, difficult to remove, easy to penetrate with fingernail; violet-brown (11F8) almost homogeneous grading to garnet-red (11E8) towards the periphery; margin concolorous with pileus, entire, thin, smooth. Context 0.3–0.9 cm thick, 0.7 cm average, fibrous, zonate, not completely homogeneous, pale-orange to light-orange (5A3, 5A4) above, to light brown (6D7) toward the tubes; with resinous bands. Pores 4-5 per mm, angular to circular, woody; pore surface pale-yellow (2A3); tubes 0.5-0.9 cm thick, up to 1.2 cm in the base, unstratified to stratified, concolorous with the inferior part of the context. Hyphal system dimitic. Contextual trama generative hyphae not observed; skeletal hyphae 6.4-13.6 μm diam., generally solid to thick-walled, non-septate, arboriform, yellowish. Hymenophoral trama as contextual trama. Pileipellis with cuticle cells 70.4-97.6 × 5.6-20.8 μm, cylindrical, apex obtuse to rarely subcapitate, entire or with one lateral protuberance; thick-walled, generally with many layers in the apex, golden-yellow, with concentric elongate granulations in the apex; dextrinoid with Melzer's reagent. Basidiospores 8.4–10.4 × (6-) 6.4-7.2 (-7.6) μm, Q = (1.25-) 1.36 -1.53, ellipsoid, apex truncate, light yellowish-brown, negative in Melzer's reagent; perisporium wrinkled, hyaline; exosporium with inter-walled pillars up to 0.3 μm thick, free; endosporium wrinkled, with apical germ pore. Basidia not seen. Cystidia absent.



Figs. 11-13. Microscopy of *Ganoderma perzonatum* (Lectotype).
11: basidiospores, 12: cuticle cells, 13: skeletal hyphae. Scale bar = 8 μm.

Comments — The lectotype is a half basidioma in good condition. Fragments of the type in BPI consist of half of one small imbricate basidioma, two ~6 × 2.5 cm fragments, and two slices — one including pileus, context and tubes and the other with the laccate crust in both surfaces (without hymenophore) and context.

Substrata – Mango log.

Habitat – Not specified.

Specimen studied – **CUBA**, Santiago de Las Vegas, 8 November 1904, F.S. Earle 309 (Holotype: NY; Isotype: BPI).

Discussion

The type of *G. argillaceum* deposited in NY is a specimen marked as: CUBA, Province of La Habana, Santiago de Las Vegas, on dead mango log, 5 July 1904, F.S. Earle 658.

The second specimen in NY also annotated as type of *G. argillaceum* ["part of type, Earle, Cuba" (hand written label)] was collected by the same collector and presumably from the same locality; no number or other data is available. Moncalvo & Ryvarden (1997) did not refer to this collection, but J.E Wright, who did examine the specimen, wrote (1967, hand written label): "Very much like *G. perzonatum* Murr.!" M.E. Bazzalo also examined the specimen, which he referred to *G. resinaceum* (1980, hand written label). After examining the specimen ourselves, we agree with Wright that the material does not correspond to *G. argillaceum* but is morphologically related to *G. perzonatum*. However, it also differs from *G. perzonatum* in several features; consequently, we describe it above as a new species.

Ganoderma vivianimercedianum can be recognized by the flabelliform basidioma with a contracted base, light brown and not completely homogenous context, and the narrowly claviform to clavate cuticle cells with scattered granulations concentrated at the apex. The Brazilian and some Mexican specimens have resinous incrustations in the context near the pileus base that were not observed in Earle's specimen deposited in NY (which does, however, lack the very base).

Table 1 compares the main differences among *G. vivianimercedianum* and the morphologically similar *G. argillaceum*, *G. perzonatum*, and *G. resinaceum*. In general, *Ganoderma argillaceum* has larger (10.4-13.6 × 7.2-9.6 μm) basidiospores and cuticle cells without granulations. *Ganoderma perzonatum* has slightly smaller (8.4-10.4 × 6.4-7.2 μm) basidiospores, remarkable large cylindrical cuticle cells with concentric elongate granulations present only at the apex, as mentioned above. *Ganoderma resinaceum* has basidiospores similar in size (11.2-13.6 × 6.5-7.4(-8.1) μm) to *G. argillaceum* (and larger than *G. perzonatum*), narrowly clavate, almost cylindrical cuticle cells, and a context that is fibrous-spongy, homogeneous, light reddish-brown, and lacking resinous bands. Ryvarden (2004) suggested that *G. perzonatum* and *G. resinaceum* might be related, but we consider these as two independent species, each one with unique features.

Table 1. Morphologic features of *Ganoderma argillaceum, G. perzonatum, G. resinaceum* and *G. vivianimercedianum.*

Species	Context	Basidiospores	Cuticle cells	Granulations
G. argillaceum	not completely homogeneous	10.4-13.6 × 7.2-9.6 μm	clavate	no
G. perzonatum	not completely homogeneous	8.4-10.4 × (6-)6.4-7.2(-7.6)μm	cylindrical	yes
G. resinaceum	homogeneous	11.2-13.6 × 6.5-7.4 (-8.1) μm	clavate almost cylindrical	yes
G. vivianimercedianum	not completely homogeneous	8.8-11.2 (-12) × 6.4-8 μm	narrowly claviform to clavate	yes

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New records and range extensions in the North American lignicolous lichen flora

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Abstract — Based on recent intensive studies of wood-dwelling lichens especially in western North America, we report a series of new records and range extensions. Six species are reported as new to North America: *Arthonia ligniariella*, *Elixia flexella*, *Gyalideopsis helvetica*, *Lecidea scabridula*, *Lecidea symmictella* and *Xyloschistes platytropa*. *Chaenothecopsis nigra* is again confirmed for North America. *Buellia arborea*, *B. chloroleuca*, *Catillaria erysiboides*, and *Lignoscripta atroalba* are new to Canada and *Lecidea pullata* and *Xylographa trunciseda* are new to eastern North America. We also provide range extensions for all four species of *Pycnora* known from North America. In all we include new records from Alaska, Arizona, British Columbia, Colorado, Idaho, Manitoba, Montana, New Brunswick, Newfoundland, North Dakota, Northwest Territories, Nunavut, Ontario, Québec, Washington and the Yukon.

Key words — calicioid, crustose lichens, floristics, Pacific Northwest, saproxylic, wood

Introduction

The study of crustose lichens in North America is enjoying something of a renaissance. In the last 10 years, hundreds of species of crustose lichens have been reported as new to science or new to North America as a result of projects such as the Sonoran Lichen Flora (Nash et al. 2002, 2004, 2007) and intensified inventory efforts in eastern North America (e.g., Harris & Lendemer 2005) and the Pacific Northwest/western Canada (e.g., Printzen & Tønsberg 1999, Spribille et al. 2008a). The fact that the rate of new descriptions and first records is not letting up belies the potential depth of the well of lichen diversity in North America.

As part of a broad-scale study of lignicolous lichens (Spribille et al. 2008b), we have accumulated a large number of records of previously unknown or poorly documented species, mainly from northwestern North America but also from other regions. While not every record reported here necessarily comes from wood, the general purpose of the present paper is to document a series of significant new records and range extensions of predominantly lignicolous lichens.

Materials and methods

Apothecia and thallus were investigated by light microscopy on hand-cut sections, mounted in water and/or 10% KOH (hereafter K), and stained with I_{Lugol} (Merck 1.09261; hereafter IKI) or lactophenol cotton blue (Merck 1.13741). A polarizing (POL) filter was used to detect birefringent crystals. Thin layer chromatography (TLC) was carried out according to the methods described by Culberson (1972) and Culberson & Johnson (1982).

Results and discussion

Arthonia ligniariella Coppins

Arthonia ligniariella was described from Scotland by Coppins (1989) and has been reported since apparently only from Sweden (Gustavsson 1995, Thor 2008). It was originally thought to be an obligate lignicole. In British Columbia, the species was found on bark of *Thuja plicata*, a habitat that often supports species that are otherwise lignicoles. Its occurrence here was briefly mentioned by Houde et al. (2007), who also provided a description of the broader habitat setting. *A. ligniariella* can be easily recognized on account of its non-amyloid hymenium, a trait that is rare in *Arthonia* and smaller ascospores than e.g. *A. ligniaria* (Coppins 1989). It is new to North America.

> SPECIMEN EXAMINED: CANADA. British Columbia. Rocky Mountains, near border with Alberta, Albert River, 50°37.693'N, 115°32.973'W, in old-growth *Thuja plicata* forest, on underhang of *Thuja*, 1224 m, 30 Jul 2005, Spribille 16780 & Houde (hb. Spribille, ver. B. Coppins).

Arthonia spadicea Leight.

This species was originally described from Britain and has been reported from Germany and elsewhere in Europe as well as Japan (Kashiwadani & Thor 1995). In North America the species has been reported from the Great Lakes region (Hedrick & Lowe 1936, Thomson 1951, Wetmore 1981) and North Carolina (Schmitt & Slack 1990). In British Columbia the species was found on wood of a snag in old-growth *Tsuga heterophylla* forest. It may be genuinely rare here, as extensive collecting of this habitat in the inland rainforests of east-central British Columbia has so far yielded only this one specimen. *Arthonia spadicea* is characterized by its 1-septate ascospores 9.5–11 × 4–4.5 μm with unequal cells, presence of K+ violet hymenial pigments, and presence of *Trentepohlia* as photobiont. The British Columbia specimen compares well with European material; it is new to western North America.

Specimen examined: CANADA. British Columbia. Selkirk Mountains, Incomappleux River drainage, Boyd Creek, 50°51.830'N, 117°31.636'W, 1185 m, lignicolous on soft snag in old-growth *Tsuga heterophylla* forest, 23 Aug 2005, Spribille 17810 & Pettitt (CANL).

Buellia arborea Coppins & Tønsberg

Buellia arborea was first reported for North America by Tønsberg & McCune (2001) and until now has been known only from this one published record, from western Montana. The species is, in fact, not uncommon on wood in dry, low elevation *Pinus ponderosa* forests of the inland Pacific Northwest and British Columbia but may evade detection because it can only be reliably identified using TLC. It can easily be confused with *Buellia griseovirens* and *Xylographa vitiligo* s.lat., but differs from both species in having more consistently concave soralia flecked in a 'salt-and-pepper' fashion with darker soredia and in the lack of stictic or norstictic acid (instead: atranorin and pseudoplacodiolic acid; Tønsberg 1992). We report it here as new to Canada and, in a significant southward range extension, from Arizona.

Specimens examined: CANADA. British Columbia. East Kootenays, NE of Kimberley, Ta Ta Creek, 49°50.823'N, 115°47.723'W, 792 m, on decorticated log in open xeric *Pinus ponderosa* woodland, 4 Aug 2005, Spribille 17166 (hb. Spribille), 17167 (CANL, hb. Spribille); U.S.A. Arizona. Graham Co., Pinaleño Mountains, Shannon Campground, 32°41'N, 109°51'W, on decorticated tree, *Pseudotsuga* forest, 24 Sep 1977, Nash 14461 (ASU).

Buellia chloroleuca Körb.

Buellia chloroleuca is one of the most common fertile species of *Buellia* on logs in the northern Rocky Mountains. It was first reported for North America by Bungartz et al. (2007) after long having passed in North America literature under the name *Buellia zahlbruckneri* (for a discussion of the nomenclatural problems, see Bungartz et al. 2007). It is otherwise known from Europe (e.g., Nordin 2000). It can be recognized by its large *Callispora*-type ascospores which are 16–22 × 7–9.5 μm, and the presence of the xanthone 6-*O*-methylarthothelin, usually in concentrations sufficient to give a C+ orange reaction. Nordin (2004) placed it in the genus *Tetramelas*, but that genus has not been widely recognized. The predominantly lignicolous habit of *B. chloroleuca* in western North America and southern Europe contrasts with its corticolous habit in northern Europe (Nordin 2000), an ecological difference that deserves further investigation. We report it here as new to Canada (British Columbia, Yukon), Idaho, Montana and Washington.

Representative specimens examined (>20 seen): CANADA. British Columbia. Rocky Mountains, NE of Canal Flats, Dry Creek, 50°15'19"N, 115°42'53"W, 1000–1100 m, on rotten log in 30–40 yr old clearcut, 26 Jul 2004, Spribille 14779 (hb. Spribille, det. A. Nordin, 2004, also !Bungartz); ibid., E of Canal Flats, Moscow Road, 50°14.908'N, 115°30.020'W, 1182 m, 26 Jul 2005, Spribille 16507 (UPS); ibid., Spribille 14779 (CANL); East Kootenays, NE of Kimberley, Ta Ta Creek, 49°50.823'N, 115°47.723'W, 792 m, on decorticated log in open xeric *Pinus ponderosa* woodland, 4 Aug 2005, Spribille 17165 (CANL); Yukon. Carpenter Lake, Wernecke Mountains, 64°30'N, 135°06'W, dwarf birch and willow communities, with scattered clumps of white spruce, 25 Jul 1972, Scotter 19376 (CANL, filed under *Xylographa abietina*); along Alaska Highway S of Johnson's Landing, near Teslin Lake, 60°28.641'N, 133°16.527'W, 719 m, on rotten log, 8 Oct 2007, Spribille 25076 (ALA); U.S.A. Idaho. Bonner Co., Selkirk Mountains, trail to Upper Priest Lake, 48°45'N, 116°51'W, on wood of conifer log, Jul 2006, Björk 13048 (UBC); Montana. Flathead Co., near confluence of Lime and Magnesia Creeks, Collins Ranch, 48°38.793'N, 114°53.180'W, 1011 m, on rotten log, edge of *Picea* swamp, 20 Jul 2006, Spribille 20313 & Pérez-Ortega (ALA, BG); Lincoln Co., W of Eureka, Black Butte, 48°52.151'N, 115°06.701'W, 974 m, on log, 31 Jul 2006, Spribille 21240 & Pérez-Ortega (hb. Spribille); ibid., Salish Mountains, Weigel Creek, 48°28.676'N, 114°58.905'W, 1147 m, on wood, 10 Aug 2006, Spribille 21944 (BG); Washington. Douglas Co., Badger Mountain, 47°36'N, 120°08'W, on log of *Pinus ponderosa*, Aug 2005, Björk 12188 (UBC).

Catillaria erysiboides (Nyl.) Th. Fr.

This species was first reported for North America by Printzen & Tønsberg (1999), based on the 19th century Wilhelm Suksdorf collection described by Willey (1887) as *Arthonia carneorufa*. There are no other published records for North America to our knowledge. We have found the species sporadically, primarily on the sides of rotten logs in dry forests, in areas where grass or herbs grow up around the logs, rarely on the tops of logs, other specimens have been gathered from vertical wood surfaces on snags and stumps, always near ground level. The species can easily be recognized by its combination of 1-septate ascospores with one cell larger than the other (likely why Willey assigned it to *Arthonia*), the presence of a well developed excipulum, and the '*Porpidia*-type' ascus. We report it here as new to Canada.

Specimens examined: CANADA. British Columbia. Rocky Mountains, E of Canal Flats, Moscow Road, 50°20.825'N, 115°35.886'W, 1069 m, 1 Aug 2005, Spribille 16938 (hb. Spribille); East Kootenays, E of Canal Flats, Kootenay River valley, Dry Creek, 50°15.120'N, 115°42.693'W, 1122 m, on decorticated log, 4 Aug 2005, Spribille 17206 (CANL); Thompson Plateau, Opax Mountain silvicultural study site, 20 km NW of Kamloops, 50°49'N, 120°28'W, on wood of snag near ground-level, Sep 2007, Björk 15094 (UBC).

Chaenothecopsis nigra Tibell

This species occurs on wood, over thalli of *Chaenotheca* species or on groups of free-living algae and has been reported from New Zealand (type locality), South America, Great Britain, Lithuania, Poland, Russia, Sweden and Japan

(Titov 2006). Rikkinen (2003) reported *Chaenothecopsis nigra* from Oregon with 'cf.' on account of deviations in ascospore size. It was also reported, with a question mark, by Harris & Lendemer (2005), although the two characters cited by the latter (dark ascospore septum, but dark greenish KOH– stalk) could also lead to other *Chaenothecopsis* species. Titov (2006) provided the first confirmed record from North America, from Mt. Cain on Vancouver Island. We report the first confirmed specimen here for the United States.

Specimen examined: U.S.A. Idaho. North Fork Clearwater River drainage, Isabella Creek, 46°52'N, 115°37'W, on cubed cracked wood on leaning snag, 8 Jul 2001, Spribille 11543-B & Hauck (UPS, det. L. Tibell).

Cladonia botrytes (K.G. Hagen) Willd.

Cladonia botrytes is one of the few obligately lignicolous macrolichens (Spribille et al. 2008b). Although the species is well known in the boreal zone of North America and has been reported from British Columbia and Alaska, it has been reported south of Canada in the west only from Montana (DeBolt & McCune 1993), where it is locally common in Flathead and Lincoln Counties. We report the species here as new to Washington.

Specimen examined: U.S.A. Washington. Pend Oreille Co., Frater Lake, 48°39.266'N, 117°29.090'W, 968 m, on stump, 19 Aug 2005, Spribille 17479 (WTU).

Elixia flexella (Ach.) Lumbsch

Elixia flexella was long treated within the genus *Lithographa* but was recognized as a distinct, monospecific genus by Lumbsch (1997). The species was described from France and subsequently reported from the United Kingdom (Hawksworth et al. 1980), Austria and Italy (Lumbsch 1997), eastern Europe (e.g., Miądlikowska 1993), Scandinavia (Santesson et al. 2004), the Komi Republic, western Russia (Hermansson et al. 2006) and Japan (Kurokawa & Kashiwadani 2006). It can be recognized by the distinctive folded, involute exciple that often gives the mature apothecia a triangular or square shape, IKI+ reddish hymenium, and simple ascospores 6–8 × 3–4.5 µm. It is new for North America.

Specimens examined: CANADA. British Columbia. Southern interior, Sicamous Creek Silvicultural Research Site, 50°49'N, 118°50'W, on snag, north-facing slope, subalpine forest of *Abies lasiocarpa* and *Picea engelmannii*, 27 Jul 1997, Goward 97-393 (UBC, det. G. Thor); Cariboo Mountains, Wells Gray Provincial Park, shortly S of the park road immediately north of Second Canyon Creek, 51°46.2'N, 120°0.6'W, weathered wood of a *Pseudotsuga* stump, 27 Feb 2006, Björk 12191 (UBC); U.S.A. Idaho. Shoshone Co., St. Maries River Valley, 47°3.5'N, 116°17.9'W, swamp forest shortly east of Hwy. 3 between Clarkia and Emerald Creek, on bark of *Thuja* trunk, 11 Apr 2008, Björk 15312 (UBC); Washington. Skamania Co., Columbia River Gorge, 45°42.9'N, 120°49.2'W, on wood of a *Pseudotsuga* snag, 19 Mar 2007, Björk 14088 (UBC).

Gyalideopsis helvetica van den Boom & Vězda

This distinctive species was first described from Austria by van den Boom & Vězda (2000), and remains one of the rarely reported lignicolous lichens, being known only from Switzerland, Germany and Austria (Hafellner et al. 2005) and Sweden (Hermansson et al. 2008). When sterile it is difficult to recognize as the thallus consists only of a thin film interrupted by patches of concave goniocystangia (van den Boom & Vězda 2000). Fertile specimens are more easily recognized by the translucent, 'gummy bear-like' apothecia and distinctive muriform ascospores. The species has only been found once during our field studies of lignicolous lichens, and, fortunately, it was fertile. It is new to North America.

Specimen examined: CANADA. British Columbia. East Kootenays, E of Canal Flats, Kootenay River valley, Dry Creek, 50°15.125'N, 115°42.725'W, 1126 m, on decorticated log, 4 Aug 2005, Spribille 17193 (hb. Spribille, mixed with *Absconditella lignicola*).

Hypocenomyce anthracophila (Nyl.) P. James & Gotth. Schneid.

This species is widely reported for the Great Lakes region, the American Southwest (e.g., Timdal 2002) and South Dakota (Wetmore 1967) and is also mapped for Alberta, Manitoba and California by Brodo et al. (2001). It was first reported for northwest North America by Goward et al. (1994) from British Columbia, but it appears to be rare in the northwest of the continent. We report it here as new to Washington.

Specimen examined: U.S.A. Washington. Skamania Co., Columbia River Gorge, 45°42.9'N, 120°49.2'W, on wood of a *Pseudotsuga* snag, 100 m, 19 Mar 2007, Björk 14086 (UBC).

Lecidea pullata (Norman) Th. Fr.

Lecidea pullata was first reported for North America by Goward & Thor (1992) based on a specimen collected in coastal British Columbia. It occurs on a wide array of bark and wood substrates and is much more common than the few records would seem to indicate. We report *Lecidea pullata* as new to the United States (Colorado, Montana) and eastern Canada (Québec).

Representative specimens examined (>20 seen): CANADA. Québec. Gaspé West Co., Mont Albert, La Potatiere T.P., on decaying wood, 1971, Muhle s.n. (CANL, filed under *Xylographa abietina*); U.S.A. Colorado. Clear Creek Co., N face of Squaw Mountain along Squaw Pass Road, 39°41'30"N, 105°30'W, on wood, 16 Aug 1983, Nash 22134 (ASU, filed under *Xylographa parallela* and mixed with *Pycnora sorophora*); Montana. Lincoln Co., northern Salish Mountains, Cliff Creek, 48°35'30"N, 115°06'W, on *Populus balsamifera* bark, 17 Sep 1996, Spribille 6376 (BG, hb. Spribille; det. T. Tønsberg).

Lecidea scabridula Hedl., nom. illegit., non Müll. Arg.

Lecidea scabridula is known only from a set of type material collected by Johan Theodor Hedlund in Sweden (Hedlund 1892). Printzen (1995) reported that the type material had been studied by Brian Coppins and tentatively assigned to the order *Agyriales* based on ascus characteristics. The species possesses a highly unique set of characteristics: the ascus is quite similar to the '*Agyriales*-type' (but see Lumbsch et al. 2007), ascospores are simple, 7–12 × 4–5 μm and the exciple and epihymenium are carbonized. However, unlike in *Ptychographa*, another genus with 'Agyrialean' ascus type and carbonized exciple, the apothecia are rounded, not lirellate. The systematic position of the species is the subject of an ongoing study (Spribille & Lumbsch, in prep.), in which a new name will be created to replace the currently illegitimate one. In the interim, we report it here as new to North America as a voucher for the inclusion of the species by Spribille et al. (2008b).

Specimens examined: CANADA. British Columbia. East Kootenays, White River drainage, SE of Canal Flats, 50°14.522'N, 115°29.283'W, 1164 m, on decorticated log with *Placynthiella icmalea* and *Trapeliopsis flexuosa*, 28 Jul 2005, Spribille 16631 (hb. Spribille); ibid., Kootenay River drainage NE of Canal Flats, 50°15.159'N, 115°42.517'W, 1069 m, on decorticated log with *Xylographa vitiligo*, *Ochrolechia gowardii*, *Lecidea rubrocastanea*, 5 Aug 2005, Spribille 17249 (hb. Spribille); Northwest Territories. Vicinity of Glacier (Brintnell) Lake, near camp, 62°5'N, 127°35'W, dead wood on ground, 18 Aug 1939, Raup 3557 (CANL, FH, both filed under *Xylographa parallela*); U.S.A. Washington. Okanagan Co., Okanogan National Forest, trail to Roger Lake, off Forest Service Rd. 39, 48°39'30"N, 119°57'50"W, ca. 1775 m, on conifer wood, 14 Oct 1993, Ryan 30733 (ASU, filed under *Xylographa abietina*).

Lecidea symmictella Nyl.

Lecidea symmictella is a widespread though seldom collected lignicolous species in northern (Foucard 2001) and central Europe (van den Boom 2002). Contrary to the suggestion of the name, the species bears little resemblance to *Lecanora symmicta*. *L. symmictella* is characterized by its small apothecia 0.1–0.3 mm diam., simple narrowly ellipsoid ascospores 3–8 × 1.5–2.65 μm, ±*Micarea*-type ascus (not *Catillaria*-type as stated by Foucard 2001), and the presence of a POL+ granular epihymenium (Z. Palice, pers. comm.). In North America, the species may belong to a continental boreal element. It is new to North America (Montana and Ontario).

Specimens examined: CANADA. Ontario. Thunder Bay District, Pine Portage, 23 miles N of Nipigon, 49°20'N, 88°20'W, boreal *Picea mariana-Abies* forest, on rotting log, 26 Aug 1965, Brodo 6137 (CANL, filed under *Xylographa abietina*); U.S.A. Montana. Flathead Co., Salish Mtns., near confluence of Lime and Magnesia Creeks, Collins Ranch, 48°38.793'N, 114°53.180'W, 1011 m, on hard decorticated log, 20 Jul 2006, Spribille 20251-A & Pérez-Ortega (hb. Spribille).

Lignoscripta atroalba B.D. Ryan & T.H. Nash

This lichen was described as a new genus and species by Ryan (2005), differing from *Xylographa* on account of its intense greenish, HNO_3+ reddish epihymenial pigments, pruinose exciple, and bacilliform conidia. At the time, only a single specimen from Arizona was reported. We report it here as new to Canada (British Columbia) and the U.S. states of Montana and North Dakota.

> Specimens examined: CANADA. British Columbia. East Kootenays, W of Invermere, Toby Creek canyon, on wood of abandoned bridge, 20 Jul 2004, Spribille 15316 & Goward (hb. Spribille). U.S.A. Montana. Lincoln Co., 1 km N of Rexford, 48°54.683'N, 115°09.629'W, 800 m, on wood of old guard rail, 30 Jul 2006, Spribille 21011 (hb. Spribille); Teton Co., NW of Choteau, on decorticated *Pinus flexilis* branches, 26 Jul 2006, Spribille 20668 & Pérez-Ortega (F); North Dakota. Billings Co., Theodore Roosevelt National Park, South Unit, at Badlands Overlook (3.5 mi E of Medora); Sec. 20, T140N, R101W, on north facing slope with junipers, on juniper log, 25 Jul 1982, Wetmore 45080 (ASU); McKenzie Co., Theodore Roosevelt National Park, N Unit, on south side of Cedar Canyon (14 mi SSW of Watford City), Sec. 25, T148N, R100W [added in pencil: 47°36'45"N, 103°22'54"W]; on north facing slope with juniper and few ash, on juniper log, 20 Jul 1982, Wetmore 44812 (CANL).

Micarea melaena (Nyl.) Hedl.

This is one of the most widely reported epiphytic species of *Micarea*, being known from Eurasia (Czarnota 2007), Japan (Kurokawa & Kashiwadani 2006) and eastern North America (e.g., Wetmore 1981, Harris & Lendemer 2006) and in the west from Alaska (Moser et al. 1979) and Wyoming (Eversman et al. 2002). Remarkably, the species has not been reported until now from the Pacific Northwest, though it is mapped for the Alberta Rockies by Thomson (1997); the latter specimen has not been seen by us. It is characterized by its darkly pigmented hypothecium, lack of K+ mauve epihymenial pigments and 3-septate ascospores (see illustrations in Czarnota 2007). It is new to British Columbia.

> Specimen examined: CANADA. British Columbia. Selkirk Mountains, E of Nakusp, Kuskanax River drainage, slope below Kimbol Lake, in old-growth *Tsuga heterophylla* forest, lignicolous on *Thuja plicata* wood, 9 Aug 2004, Spribille 15668, Pettitt & Wagner (hb. Spribille).

Pycnora leucococca (R. Sant.) R. Sant.

This species is known only in the sterile state, but is highly distinctive on account of its lip-shaped soralia and presence of alectorialic acid. The species has rarely been reported for North America, but is common in moist areas of the west, where it was first reported for British Columbia by Moberg (1986, but unvouchered), Brodo (1991, as an associate of *Ochrolechia gowardii*) and Goward & Thor (1992). Brodo (1991) also reported it as an associate of his *Ochrolechia* sp. 8 in the Labrador-Québec border region of eastern Canada. It occurs on a wide array of bark and wood substrates. We report the species here from southern Nunavut, a substantial range extension halfway between the two currently known eastern and western ranges in North America; this specimen too was an incidental collection, an associate of *Xylographa opegraphella* collected in a study by Kershaw in what was then still a part of northwestern Ontario. We also report it as new to the United States (Montana).

Representative specimens examined (>40 seen): CANADA. Nunavut. East Pen Island, 56°45'N, 88°45'W, raised beach systems, on drift wood, Jul 1971, Kershaw s.n. (CANL.-38115, filed under *Xylographa opegraphella*). U.S.A. Montana. Lincoln Co., Yaak Valley, Can Creek, c. 48°44.899'N, 115°38.239'W, 1105 m, corticolous on *Abies lasiocarpa*, 7 Nov 2007, Spribille s.n. (hb. Spribille).

Pycnora praestabilis (Nyl.) Hafellner

This species is similar to *Pycnora xanthococca* but is more robust (in our material) and has longer conidia (Timdal 1984). A specimen has also been seen by us from Idaho (GZU) but has apparently been misplaced in that herbarium.

Specimen examined: U.S.A. Montana. Ravalli Co., Bitterroot Range, summit of Ingomar Peak, 46°13'N, 114°25'W, 2590 m, 29 Aug 1982, McCune 12721 (hb. McCune).

Pycnora sorophora **(Vain.) Hafellner**

Like *Pycnora leucococca*, this species is often overlooked and rarely reported, and also as with that species, it is characterized the presence of alectorialic acid and develops a pinkish colour over time in the herbarium. Unlike *P. leucococca*, it develops terminal, not marginal soralia and the thallus often quickly completely disintegrates into soredia (Tønsberg 1992). It is widespread and occurs mostly on wood although it has been found on both wood and bark in western North America (Arizona: Timdal 2002; California: Williams & Sillett 2007; Montana: Hauck & Spribille 2005). We report the species here as new to Alaska, British Columbia, Colorado, Idaho, Manitoba, Nunavut and Washington.

Representative specimens examined (>50 seen): CANADA. British Columbia. Thompson Plateau, 20 km NW of Kamloops, Opax Mountain Silvicultural Study Site, on wood of conifer snag 50°49'N, 120°28'W, Sep 2006, Björk 13420 (UBC); Manitoba. 5 miles S of Putahow Lake, 59°45'N, 100°43'W, in *Picea mariana-Cladina* stand on fallen black spruce, 18 Jun 1973, Wong 1006 (CANL, filed under *Xylographa abietina*); Nunavut. East Pen Island, 56°45'N, 88°45'W, raised beach systems, on drift wood, Jul 1971, Kershaw s.n. (CANL., filed under *Xylographa vitiligo*, mixed with *Pycnora leucococca*); U.S.A. Alaska. Skagway Fjord, west side of Taiya River, 59°32.568'N, 135°20.693'W, 25 m elev., corticolous on *Picea sitchensis* trunk, 6 Oct 2007, Spribille 24748 (hb. Klondike NHP); Colorado. Clear Creek Co., N face of Squaw Mountain along Squaw Pass Road, 39°41'30"N, 105°30'W, on wood, 16 Aug 1983, Nash 22134 (ASU, filed under *Xylographa parallela*); Idaho. Bonner Co., Cabinet Mountains, University of Idaho Experimental Forest, Antelope Lake, 48°8'N, 116°10'W, on wood of conifer snag, Björk 14229 (UBC); Washington. Pend Oreille Co., Frater Lake, 48°39.266'N, 117°29.090'W, 968 m, on snag, 19 Aug 2005, Spribille 17469 (WTU); Spokane Co., Riverside State Park, near the Bowl & Pitcher overlook, 47°42'N, 117°30'W, wood of *Pinus ponderosa* log on talus, Björk 14135 (UBC).

Pycnora xanthococca (Sommerf.) Hafellner

Pycnora xanthococca differs from the two previous species of *Pycnora* in being consistently fertile, but shares with them the characteristic presence of alectorialic acid in the thallus. In northern Europe, *P. xanthococca* is considered to be an obligate lignicole (Spribille et al. 2008b), but we have found it in western North America also on bark of *Pseudotsuga menziesii*. It has otherwise been reported from California (Ryan & Nash 1991, Williams & Sillett 2007), South Dakota (Wetmore 1967), North Dakota (Wetmore 1985) and Wyoming (Eversman et al. 2002). We report *P. xanthococca* here as new to northwestern North America.

Specimens examined: CANADA. British Columbia. Slocan Valley, Perry Ridge trail, corticolous on *Pseudotsuga*, 26 Jun 2004, Spribille 15173 (CANL); U.S.A. Idaho. Bonner Co., Priest River Experimental Forest, behind headquarters, 48°21.30'N, 116°50.19'W, 730 m, lignicolous on *Pseudotsuga* branches, 24 Jul 2004, Spribille 15342 (BG, hb. Spribille); Montana. Lincoln Co., northern Salish Mountains, bedrock meadow along Forest Service Rd. 494, 48°37.224'N, 115°04.037'W, 1491 m, on *Pseudotsuga* bark in island of trees in bedrock meadow, 2 Aug 2004, Spribille 15408 & Wagner (hb. Spribille); same locality, 23 Jul 2006, Spribille 20470 & Abrahamczyk (BG, CANL).

Xylographa trunciseda (Th. Fr.) Minks ex Redinger

This species has been previously reported in North America only from the Queen Charlotte Islands (Brodo 1995), but is in fact common in inland British Columbia (e.g., Bunnell et al. 2008) south to northwest Montana and northern Idaho in humid forests. The species can be easily recognized by the presence of regularly (American-) football-shaped apothecia produced in chains, with younger apothecia leading each chain and older apothecia often dying out, and the presence of the unknown substance referred to by Brodo (1992) as "Xhn-1" (in TLC producing a LW UV+ blue spot in Rf classes A1/2, B3, C2, yellowish after charring). The only described species with which it might be confused is *Xylographa hians* Willey, which has a nearly identical habit but possesses stictic acid (Brodo 1992). *Xylographa trunciseda* is a loyal obligate lignicole wherever it occurs. It is so far known from Europe and the previous report from British Columbia; we report it here as new to eastern North America (New Brunswick, Newfoundland) and the United States (Colorado, Idaho, Montana).

Representative specimens examined (>20 seen): CANADA. New Brunswick. Kent Co., Kouchibouguac National Park, Rankin's Brook, 46°50'N, 64°59'W, steep bank to brook with *Tsuga canadensis* and *Pinus strobus*, on dead conifer stump, 23 Aug 1978, Egger 884 (CANL); Newfoundland. Gros Morne National Park: 3.2 km SW of St. Paul's (35 km N of Rocky Harbour), in black spruce island with black spruce, balsam fir, birch and alder, 24 Jun 1981, Wetmore 42781 (CANL, filed under *Xylographa vitiligo*); U.S.A. Colorado. Garfield Co. White River Natl. Forest NW of Meadow Lake Campground on E side of road, Hale, 39°48'N, 107°33W, on wood, 24 Jun 1992, Nash 31936 (ASU); Idaho. Bonner Co., Canyon Creek Research Natural Area, 48°21.97'N, 116°47.96'W, 790 m, lignicolous on fallen wood, 24 Jul 2004, Spribille 15365 (hb. Spribille); Shoshone

Co., North Fork Coeur d'Alene River, 47°40'N, 115°59'W, wood of conifer log, 1000 m, May 2004, Björk 8643 (UBC); Montana. Lincoln Co., northern Salish Mountains, Gray Creek, 48°30.432'N, 114°57.048'W, 1168 m, on rotten log, 9 Aug 2006, Spribille 21821 (hb. Spribille).

Xyloschistes platytropa (Nyl.) Vain.

This species was described from Finland by Nylander (1868) as a *Xylographa* and assigned to the new monotypic genus by Vainio (1883), who added new records from Karelia and Lappland. It has rarely been reported since, e.g., from Spain (Etayo 1990, as a new variety; also Aragón et al. 2004), Mongolia (Biazrov et al. 1989) and the Russian Far East (Sikhote-Alin Mountains; Chabanenko 2002). The species is characterized by muriform ascospores 20–30 × 6–8 µm, 1 per ascus (rarely 2; Nylander 1868), and immersed thallus forming a whitish patch on wood. The systematic position of the genus is poorly studied but it is thought to have affinities to the *Ostropales*. It is new to North America.

Specimen examined: CANADA. British Columbia. West Kootenay region, Mount Revelstoke National Park, Nelson Historic Site, 51°01'N, 118°12'W, 580 m, decorticated branch of *Pinus monticola* in rain forest, 2 Aug 2005, Goward 05-242 (UBC).

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Coltricia fragilissima, a new record for Brazil

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Abstract — *Coltricia fragilissima* is reported from Parque Natural Municipal de Porto Velho, in the State of Rondônia, Brazilian Amazonia. This is only the third collection of this taxon from South America and the first report from Brazil. A description of *C. fragilissima* and a key to the six species of *Coltricia* reported from Brazil are provided.

Key words — fungi, *Hymenochaetaceae*

Introduction

Coltricia is a cosmopolitan genus described by Gray (1821) characterised by its stipitate, light-coloured basidiomata, monomitic hyphal system, hyaline to pale rusty brown, simple septate generative hyphae, and cylindrical to ellipsoidal basidiospores that are golden yellow to rusty brown and slightly dextrinoid in Melzer's reagent (Ryvarden 2004).

Five species of *Coltricia* have been recorded from Brazil: *C. barbata* Ryvarden & de Meijer, *C. cinnamomea* (Jacq.) Murrill, *C. duportii* (Pat.) Ryvarden, *C. perennis* (L.) Murrill, and *C. hamata* (Romell) Ryvarden. Some references about the genus in Brazil are found in the works of Torrend (1926, 1938), Fidalgo (1968), Ryvarden & de Meijer (2002), and Gibertoni *et al.* (2004), which reported or described species collected in North, Northeast and South Brazil. *C. fragilissima* was described from French Guyana, and has been reported from Nigeria and Venezuela (Ryvarden 1982, 2004).

A description of *C. fragilissima* based on a collection from the Brazilian Amazonia and a key to the Brazilian species of the genus are presented below.

Material and methods

The Parque Natural Municipal de Porto Velho is located in the state of Rondônia. It covers an area of 390.821ha, of which 80% is composed of open ombrophilous forest and the rest by secondary vegetation.

The basidiomata were analysed macro- (shape, colour, hymenial surface) and micromorphologically (hyphal system, presence/absence and size of sterile structures and basidiospores). Micromorphological observations were made from slide preparations in 5% KOH, stained with 1% of aqueous phloxine, and Melzer's reagent (Ryvarden 1991). Colour designation followed Watling (1969). The specimens were deposited in the Herbarium Dr. Ary Tupinambá Penna Pinheiro (HFSL), Faculdade São Lucas, Rondônia, and in the Herbarium Padre Camille Torrend (URM) of the Universidade Federal de Pernambuco, Brazil.

Taxonomy

Coltricia fragilissima (Mont.) Ryvarden, Nordic J. Bot. 2(1): 78 (1982).

Basidiomata annual, laterally stipitate, pileus circular, infundibiliform, 3.5–3.7 × 2.2–2.4 cm. Stipe short, 3.5 × 1.5 cm, with a basal mycelial disk at the base, velutinus, fulvous (12). Abhymenial surface glabrous to velutinus, fulvous (12). Margin entire, involute when dry. Context thin. Hymenial surface poroid, pores angular, 2–4 mm, fulvous (12). Hyphal structure monomitic; generative hyphae hyaline, simple-septate, golden brown, 3.5–5 µm. Setae absent. Basidia clavate, 15–18 × 4–6 µm. Basidiospores hyaline, oblong ellipsoid, smooth, thin-walled, 5–6 (7) × 3–3.5 (4) µm.

MATERIAL EXAMINED: BRAZIL. Rondônia: Porto Velho, Parque Natural Municipal de Porto Velho, XII.2007, *A. C. Gomes-Silva* 69-70 (URM 78898, URM 78899).

REMARKS: Previous studies of *C. fragilissima* were based on material collected in Venezuela and Nigeria (Ryvarden 1982, 2004). The species is characterized by the short stipe, azonate abhymenial surface, basidiomata of homogeneous colour, and basidiospores ellipsoid and hyaline (6–7 (8) × 3–3.5 (4) µm). *C. barbata* differs by the zonate abhymenial surface, longer stipe, and globose to subglobose basidiospores (5–6 µm) (Ryvarden & de Meijer 2002), while *C. cinnamomea* has oblong to ellipsoid, golden yellow basidiospores (6.5–8 × 5–6 µm) (Ryvarden 2004). The specimens of *C. cinnamomea* collected in areas of restinga were initially identified as *C. duportii* (Rajchenberg & de Meijer 1990, Ryvarden & de Meijer 2002), which differs by having ellipsoid, brown basidiospores (8–10 × 6–7 µm). *C. perennis* was reported by Ryvarden & de Meijer (2002), who considered it an exotic species, because it is believed that it was probably introduced in Brazil along with the plantations of *Pinus*. *C. hamata* is distinguished by its dark, hooked setae. The Brazilian *C. fragilissima* differs macromorphologically from the description of Ryvarden (2004) by the presence of a mycelial disk at the base, and micromorphologically by having slightly larger basidiospores.

Key to the Brazilian species of *Coltricia*

1a. Setae or setal hyphae present .... *C. hamata*
1b. Setae or setal hyphae absent 2

2a. Basidiospores up to 6 μm 3
2b. Basidiospores longer than 6 μm 4

3a. Margin ciliate, 4–9 pores/mm, basidiospores golden yellow to rusty brown,
globose to suglobose .... *C. barbata*
3b. Margin not ciliate, 2–4 pores/mm, basidiospores hyaline,
oblong ellipsoid .... *C. fragilissima*

4a. Abhymenial surface azonate, basidiospores rusty brown .... *C. duportii*
4b. Abhymenial surface zonate, basidiospores yellowish 5

5a. Basidiospores pale yellowish brown, ellipsoid to cylindrical ellipsoid,
exotic species associated with *Pinus* .... *C. perennis*
5b. Basidiospores golden yellow, oblong to ellipsoid, cosmopolitan species
.... *C. cinnamomea*

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Notes on two boletes with tiny basidioma in tropical China

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Abstract — Two species of boletes with minute basidioma, *Boletus coccineinanus* and *B. patouillardii*, were described and illustrated based on materials made in tropical Yunnan, southwestern China. Both of them are new to China. Comparisons to other similar species were made. *Boletus minimus*, originally described from southeastern China, is regarded as a synonym of *B. patouillardii.*

Key words — taxonomy, morphology, *Boletales*, *Basidiomycota*

Introduction

During a study of boletes from Yunnan Province, China, we came across two boletes with minute basidioma. They could easily be overlooked in the field due to their small sizes. Descriptions and illustrations for the each species are provided herein, and they are compared with similar species described from China and Japan.

Materials and methods

Revived tissues were mounted in 5% KOH for microscopic examination. The abbreviation [n/m/p] shall mean n basidiospores measured from m basidiocarps of p collections. Dimensions of basidiospores excluding the apiculus are given using notation of the form (a) b–c (d). The range b–c contains a minimum of 90% of the measured values. Extreme values a and d are given in parentheses. Q refers to the length/width ratio of basidiospores; **Q** refers to the average Q of all basidiospores ± sample standard deviation. Herbarium abbreviations follow Holmgren et al. (1990) but with one exception that is not included in Index Herbariorum: HKAS—the Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences.

Taxonomy

Boletus coccineinanus Corner,

Boletus in Malaysia (Singapore): 152, Fig. 47, Pl. 11/2 (1972). Figs. 1–4

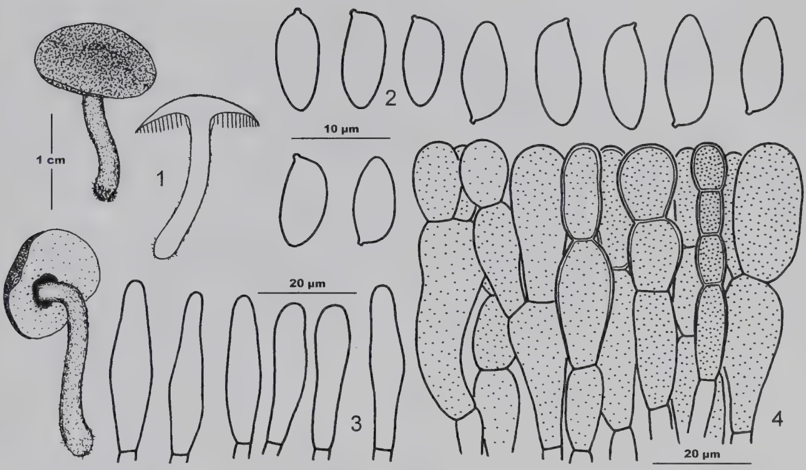
Basidiomata (Fig. 1) very small. Pileus 10–12 mm in diam., convex to plano-convex; surface dry, red to vinaceous red, often cracked into minute squamules; context white to whitish, unchanging. Hymenophore poroid, carneous, unchanging when bruised, slightly depressed around apex of stipe; pores 2–3/mm, but becoming somewhat larger towards apex of stipe; color of tubes unknown. Stipe 12–20 × 2–3 mm, subequal, often curved near apex or base, smooth, without nets, sometimes with longitudinal striations, nearly glabrous or with very small fibrillose squamules, dry, mostly concolorous with pileus, whitish at apex, with ochre to yellow mycelium at base; context yellowish but ochreous yellow at base, unchanging. Annulus absent.

Tube Trama boletoid with deep-colored mediostratum and light-colored lateral strata. Basidia 25–30 × 8–10 µm, clavate, hyaline, 4-spored, no clamps observed on basal septa. Basidiospores (Fig. 2) [35/2/1] (8) 8.5–10.5 (11) × 4–5 µm, Q = (1.55) 1.88–2.33 (2.44) (**Q** = 2.0 ± 0.17), yellowish in KOH, slightly thick-walled (< 0.5 µm), smooth, boletoid to subamygdaliform in side view and usually without a suprahilar depression, nearly ellipsoid in ventral view. Cheilocystidia (Fig. 3) 30–40 × 6–8 µm, subfusiform to narrowly clavate, thin-walled, nearly colorless and hyaline. Pleurocystidia similar to cheilocystidia in form and size, but rare. Pileipellis (Fig. 4) an epithelioid trichoderm composed of more or less vertically arranged, moniliform hyphae with ovoid, subglobose to ellipsoid, often thick-walled (up to 1.5 µm thick), reddish brown vacuolar pigmented cells (10–30 × 8–15 µm) 2–4 in chains. Clamps absent in all tissues.

Habit, habitat, distribution and season — Single or in groups, on soil in tropical forest; Tropical China, Indonesia (Corner 1974), Malaysia (Corner 1972), and Thailand (Watling 2001); August–November.

Specimen examined — **CHINA. Yunnan Province: Longchuan County**, along a roadside near Nongxianhe, alt. 1200 m, 25.VIII.2003, H. Luo *62* (HKAS 43601).

Comments—*Boletus coccineinanus* is well characterized by its very small basidioma with a red pileus, a red stipe with an ochre basal mycelium, a pink to pinkish hymenophore, relatively subamygdaliform basidiospores and an epithelioid trichoderm of the pileipellis with thick-walled cells. Corner (1972) put this species in the alliance around *B. nanus* of *Boletus* subgen. *Tylopilus.* Because molecular phylogenetic studies of many species of boletes including *B. coccineinanus* are still unavailable, we prefer to keep it in the genus *Boletus* temporarily. The characters observed from the Chinese material agrees relatively well with the protologue of *B. coccineinanus.* In the protologue the



Figs. 1–4: *Boletus coccineianus* (HKAS 43601).
1. Basidiomata; 2. Basidiospores; 3. Cheilocystidia; 4. Pileipellis.

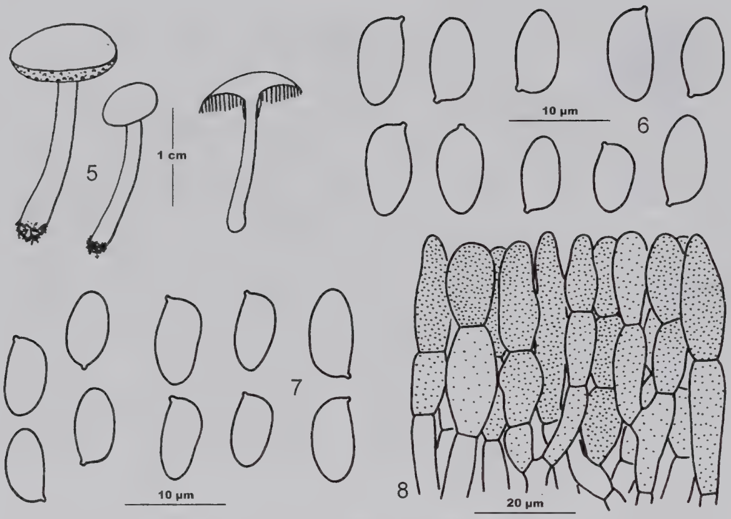
cheilocystidia were described as clavate with pink walls. The pink wall probably can only be observed in water with fresh material. In the Chinese material the pink color of the cell wall couldn't be discernible. This species has not been reported from China before (see Bi et al. 1994, 1997; Zang 2006).

Boletus patouillardii Singer, Am. Middl. Nat. 37: 55 (1947). Figs. 5–9

≡ *Porolaschia bicolor* Pat., Bull. Soc. Mycol. France 39: 54 (1923).
= *Boletus minimus* M. Zang & N.L. Huang, Acta Bot. Yunnanica 24: 723, fig. 1/1–6 (2002).

Basidiomata (Fig. 5) very small. Pileus 8–17 mm in diam., convex to plano-convex; surface dry, dark red to orange red when fresh, becoming dark brown when dried, nearly glabrous to finely tomentose; context yellowish, unchanging. Hymenophore poroid, yellowish to yellow at first, but becoming pale yellow-brown when mature, slightly depressed around apex of stipe; pores 2(3)/mm, but becoming larger towards apex of stipe and 1/mm, and often forming lamella-like "teeth" adnate to apex of stipe and, thus, hymenophore somewhat appearing decurrent. Stipe 10–20 × 1–3 mm, subcylindrical, smooth, without nets or striations, nearly glabrous or with fine fibrillose squamules, dry, vinaceous, with yellow to yellowish mycelium at base. Annulus absent.

Tube Trama boletoid with deep-colored mediostratum and light-colored lateral strata. Basidia 25–30 × 7–10 µm, clavate, hyaline, 4-spored, no clamps observed on basal septa. Basidiospores (Figs. 6–7) [63/3/2] (6.5) 7–8.5 (9) × 4–5 µm, Q = (1.56) 1.63–1.90 (2.0) (Q = 1.78 ± 0.11), ochreous to yellowish, slightly thick-walled (< 0.5 µm), smooth, ellipsoid to subamygdaliform in side



Figs. 5–8: *Boletus patouillardii.*
5. Basidiomata (holotype); 6. Basidiospores (holotype);
7. Basidiospores (HKAS 43602); 8. Pileipellis (HKAS 43602).

view and usually without a suprahilar depression, ellipsoid in ventral view. Cheilocystidia 30–50 × 5–8 µm, subfusiform to fusiform, nearly colorless and hyaline, thin-walled. Pleurocystidia similar to cheilocystidia in size and form, but rare. Pileipellis (Figs. 8–9) an epithelioid trichoderm composed of more or less vertically arranged, moniliform hyphal elements 2–4 in chains, 10–40 × 7–16 µm, ellipsoid, ovoid, subglobose, thin-walled with yellowish, yellow-brown to brownish vacuolar pigment; terminal ones broadly ellipsoid to subfusiform or subcylindrical, with round to obtuse apices. Clamps absent in all tissues.

Habit, habitat, distribution and season — Single or in groups, on soil in forest; Cambodia, and tropical and subtropical China; July–August.

Specimens examined — CAMBODIA. **Kompong Chhnang:** Forest Reserve, 1921, M. Petelot *222* (**holotype** of *Porolaschia bicolor* and *Boletus patouillardii*, FH-Pat. Herb.3644). **CHINA. Yunnan Province: Longchuan County**, along a roadside near Nongxianhe, alt. 1200 m, 25.VIII.2003, H. Luo *63* (HKAS 43602); **Fujian Province: Yongchun County**, Niumulin Nature Reserve, 3.VII.2001, N.L. Huang *703* (HKAS 39514, holotype of *Boletus minimus*).

Comments—*Boletus patouillardii* is well characterized by its very small basidioma with a red pileus, and a red stipe with a yellow basal mycelium, a yellowish to yellow hymenophore unchanging in color when injured, relatively short ellipsoid to subamygdaliform basidiospores and an epithelioid trichoderm of the pileipellis.

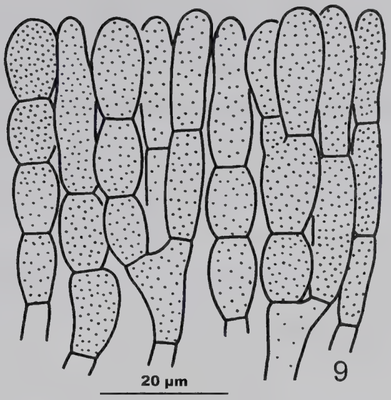


Fig. 9: *Boletus patouillardii.*
Pileipellis (holotype of *B. minimus*).

The holotype specimen did not rehydrate well, thus microscopic studies were limited. Cystidia and pileipellis were not recovered, and basidiospores were [42/2/1] (6.5) 7–9 × 4–5 µm, Q = (1.56) 1.63–1.89 (2.0) (Q = 1.75 ± 0.11). The name *Porolaschia bicolor* was published by Patouillard (1923), based on the same type specimen. Singer was aware that Patouillard had examined the specimen and named it as a species of *Porolaschia*, but mistakenly thought that this was merely a herbarium name (Singer 1945, 1947). *Porolaschia bicolor* cannot be recombined in *Boletus*, because the epithet is already occupied by *Boletus bicolor* Peck; thus Singer's epithet is the earliest available in *Boletus* for this taxon. Although published as a "sp. nov.", *Boletus patouillardii* should be regarded as a nom. nov. for its homotypic synonym, *Porolaschia bicolor.* This species was known only from its type collection.

Boletus minimus is apparently conspecific with *B. patouillardii* due to its minute basidioma with a red pileus, a red stipe and a yellow hymenophore. Although the base of the stipe was described as "whitish", reexamination of the holotype of *B. minimus* showed that the mycelium at the base of the stipe is yellowish. The only basidioma available for our study is unfortunately not mature. In the protologue, the basidiospores of *B. minimus* were described as "10.4–14 × 4–5.2 µm", longer than those of *B. patouillardii*. However, the line-drawings (Zang & Huang 2002, Fig. 1/4; Zang 2006, Fig. 36/4) showed that the size and the form of the spores are just within the ranges of those of *B. patouillardii*. Furthermore, the pileipellis of the holotype of *B. minimus* (Fig. 9) is very similar to that of *B. patouillardii*. Thus, *B. minimus* should be regarded as a synonym of *B. patouillardii*.

Another species with small basidiomata, *Xerocomus tengii* M. Zang et al., was described from southern subtropical China (Zang et al. 2002). Restudy of the type of *X. tengii* (HKAS 39594) revealed that the surface of the pileus is rugulose and in some areas even distinctly reticulate, the basidiospores are 10–14 × 4–5 μm, and the pileipellis is an ixotrichoderm consisting of more or less vertically arranged, frequently septate filamentous hyphae, very similar to that of *Aureoboletus thibetanus* (Pat.) Hongo & Nagas. (Yang et al. 2003). However, cystidia with refractive substance on its surface, very characteristic for *A. thibetanus*, were not observed from the holotype.

Boletus aokii Hongo, originally described from Japan, looks like *B. patouillardii*, but differs from the latter by its basidioma becoming blue on injury, longer basidiospores, and subventricose, apically tapering terminal cells in the pileipellis (Hongo 1984).

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The generic name *Leratiomyces (Agaricales)* once again

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Abstract — *Leratiomyces* was not validly published in 1998; rather it was, in fact, unintentionally validated in 2008 as a nomen novum for *Le-Ratia*. The history of these names is detailed and linked to "*Le Ratia,*" which is not a validly published name. *Le-Ratia*, which is validly published but illegitimate, is lectotypified, thereby typifying *Leratiomyces*; the new combination *Leratiomyces similis* is proposed for its type.

Key words — New Caledonia, nomenclature, *Orthotrichaceae*, secotioid, *Stropharia*

Introduction

The generic name *Leratiomyces* was adopted for a phylogenetically defined clade of agarics and secotioid gasteromycetes in a recent publication in Mycotaxon (Bridge et al. 2008) following earlier analyses by Binder et al. (1997), Bresinsky & Binder (1998), Moncalvo et al. (2002), and Walther et al. (2005). However, the cited type, "*L. similis*" (Bridge et al. 2008), was based on a name that was not validly published. This contradiction led us to investigate the nomenclature behind the name *Leratiomyces*.

History

The name "*Leratiomyces*" was proposed by Bresinsky & Binder (1998) as a 'nomen novum' for "*Le Ratia*" (Patouillard 1907) that was never validly published. New replacement names, nomina nova, can only be proposed for validly published names (Art. 7.3 & 33.4); if a name is not validly published

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it has no status (Art. 12.1). Hence use of "names" in the International Code of Botanical Nomenclature (McNeill et al. 2006) refers only to validly published names (Art. 6.3). "*Le Ratia*" Pat. was not validly published (Art. 20.3 & Ex. 7) because it consists of a two part "generic" name that, unlike species epithets that can be corrected (Art. 23.1, 60.9), cannot be "corrected" by later authors by uniting or hyphenating while retaining the original authorship and date and place of publication for priority purposes. The name *Le-Ratia* (with the hyphen) was validly published (Art. 20.3) by Saccardo & Trotter (1912) along with the binomial *Le-Ratia similis* for the original taxon detailed by Patouillard (1907) as "*Le Ratia similis*". Additionally, they validated the name *Le-Ratia smaragdina* for a species circumscribed in a second paper by Patouillard (1909) that he called "*Le Ratia smaragdina*" - also not a validly published name. Species names, such as those put forward by Patouillard (1907, 1909), cannot be validly published when the epithet is combined with a purported generic name that itself is not validly published (Art. 43.1). Authorship for *Le-Ratia* must be attributed to Saccardo & Trotter (1912), not Patouillard, and it dates from 1912, not 1907 or 1909.

Prior to validation of *Le-Ratia* Sacc. & Trotter in 1912, an earlier homonym, *Leratia* Broth. & Paris (Brotherus 1909a,b), was published for a moss in honour of the same collector, Auguste-Joseph Le Rat, who sent materials from New Caledonia (cf. Farr et al. 1979). The two names *Le-Ratia* and *Leratia* are interpreted as homonyms even though differing in one being hyphenated. For example, Brotherus & P. Sydow (Sydow 1910) incorrectly believed that the moss genus name *Leratia* was a later illegitimate homonym of "*Le Ratia* Pat.", leading them to propose unnecessarily yet another invalid, two part, replacement generic name "*Le Ratiella*" for the moss. *Leratia* continues to be in current use for mosses (Crum 1987, Goffinet et al. 1998, 2004). Additional support for treating the two generic names as homonyms comes from Wakefield's (1922) discussion of both of Patouillard's species' specimens, labeling them "*LeRatia similis*" and "*LeRatia smaragdina*". Interpreted as a later homonym of *Leratia*, the fungal *Le-Ratia* is illegitimate (Art. 53.1 & 53.3), which is one of the reasons why bryologists continue to use the generic name *Leratia*. However, the two species names, *Le-Ratia similis* and *Le-Ratia smaragdinus*, dating from 1912 (not 1907 or 1909 respectively) are legitimate (Art. 55.1).

The reasons why "*Leratiomyces*" (Bresinsky & Binder 1998) was not validly published, either as the name of a new genus or as a nomen novum for the validly published but illegitimate *Le-Ratia* (Saccardo & Trotter 1912), must be considered. Art. 33.4 dictates that after 1952 a full and direct reference be given to the author and place of publication of the replaced synonym to validate nomina nova. Unfortunately, no reference was made to Saccardo & Trotter

(1912) in the 1998 publication. Art. 33.5 allows for correction of bibliographic citations with regard to Art. 33.4. The definition of correctable citation situations covered by Art. 33.5 is governed by Art. 33.7, wherein only four case scenarios are allowed: **a)** the replaced synonym was validated earlier than the cited source (this is not the case—see below); **b)** the incorrect citation resulted from a shift in starting point dates (this does not apply here); **c)** the intended generic name has a basionym (it does not have a basionym); and **d)** when it would otherwise be the validly published name of a new taxon (discussed below).

Bresinsky & Binder listed as "Ungültige Namen" three differently spelled names that were neither validly published nor identified by a full and direct reference: "*Le Ratia* Pat. 1907. – *Le-Ratia*, Heim 1957.- *Leratia*, Smith & Singer 1959, Ainsworth 1961". Hence the fundamental criteria outlined in Art. 33.7(a) were not met. Heim appears not to have published in 1957, but did so in 1951, 1967 and 1968a,b; only in the 1951 paper did he use the hyphenated spelling, but did so inconsistently, so "1957" may be a typographical error for "1951". Smith & Singer (1959: 216) incidentally discuss "*Leratia* Pat.", spelled as such, in reference to both Patouillard's and Heim's publications. Ainsworth's (1961) publication was the Dictionary of Fungi.

Finally, it must be asked whether the requirements for valid publication of a name of a new taxon were met (Art. 33.7(d)) when "*Leratiomyces*" was proposed by Bresinsky & Binder (1998). This would require provision of a Latin diagnosis or description (Art. 36.1) and designation of a type (Art. 37.1). The authors supplied a Latin description but they designated as nomenclatural type "*Le Ratia similis* Pat. (siehe *Leratiomyces similis*)". For "*Leratiomyces similis* (Pat.) Bresinsky et Binder" the basionym was given as "*Le Ratia similis* Patouillard, Bull. Soc. Mycol. de France **23**, 52, 1907." "*Le Ratia similis* Pat." is not a validly published name and therefore citation of it cannot be construed as effectively citing a type because it is not a named species (Art. 37.3). It may be further asked if the binomial "*Leratiomyces similis*" were unintentionally validated as the name of a new taxon by meeting all such requirements. The reference to Patouillard (1907) leads to a Latin description of the taxon, but no type was designated for the name in 1998 and therefore the binomial "*Leratiomyces similis*" is not validly published. Designation of a type for a proposed generic name via citation of two names that were never validated is not an effective designation of a type under Art. 10.1 for the proposed generic name "*Leratiomyces*" (Art. 33.4), which itself must therefore be treated as not validly published. The requirements of Art. 33.7(d) were not met.

Bresinsky & Binder (1998) had intended to include four species and had proposed "new combinations" based upon "*Le Ratia atrovirens* Heim", "*Le Ratia coccinea* Massee & Wakefield", and "*Le Ratia smaragdinus* Patouillard", in addition to "*Le Ratia similis*"; none of these is a validly published name. None of the combinations is validly published because neither the generic name "*Leratiomyces*" nor any one of the basionyms is validly published (Art. 43.1). Additionally, their reference to "*Le Ratia atrovirens* Heim" referred to a publication (Heim 1968a) that lacked a Latin description or diagnosis (supplied subsequently in Heim (1968b)).

Leratiomyces was more recently adopted by Bridge et al. (2008), who proposed six additional new species combinations and one varietal combination. Although these authors were evidently unaware of the fact that "*Leratiomyces* Bresinsky & Manfr. Binder" was not validly published, they did in fact cite, along with "*Le Ratia* Pat." (acknowledged as a "nom. inval."), *Le-Ratia* Pat. ex Sacc. & Trotter as a nomenclatural (homotypic) synonym of *Leratiomyces* along with a direct and full citation to its place of publication in their synonymy for *Leratiomyces*. Although they listed the type under two designations, "*L*[*eratiomyces*] *similis* (Pat.) Bresinsky & Manfr. Binder" and "*Le Ratia similis* Pat.," neither of which is a validly published name and did not mention *Le-Ratia similis* Pat. ex Sacc. & Trotter, it is not required under Art. 37.1 that a name published as a replacement for a validly published (but illegitimate) name include citation of the type. Nor was it necessary in 1912 for Saccardo & Trotter to cite a type. Consequently Bridge et al., albeit inadvertently, have validly published *Leratiomyces*, which must therefore be attributed as *Leratiomyces* Bresinsky & Manfr. Binder ex Bridge et al., Mycotaxon 103: 115. 2008.

Despite the validation of the generic name, the binomial "*Leratiomyces similis*" for the type of the generic name has yet to be validly published. The authors, unaware of the fact that Bresinsky & Binder had not validly published *Leratiomyces*, did not mention *Le-Ratia similis* Pat. ex Sacc. & Trotter, far less give "a full and direct reference ... to its author and place of valid publication" (Art. 33.4), as would be necessary for their use of "*L. similis*" to serve as valid publication of the name. However, the seven proposed combinations of other species and varieties of *Leratiomyces* later in the paper are validly published.

One other generic name, "*Stropholoma*", was proposed by Balletto (1989) for species now placed in the "*Leratiomyces*" clade. However, Balletto intended to elevate to generic level *Naematoloma* sect. *Stropholoma* Singer (1948), but failed to provide a full and direct reference to the place of publication of the basionym. Consequently, "*Stropholoma*" is not a validly published generic name (Art. 33.4), as noted by Bridge et al. (2008).

No validly published names exist for the two fungal species labeled "*Le Ratia atrovirens*" (Heim 1968a,b) or "*Leratiomyces atrovirens*" (Bresinsky & Binder 1998) and "*Le Ratia coccinea*" (Wakefield et al. 1916, Wakefield 1920) or

"*Leratiomyces coccinea*" (Bresinsky & Binder 1998). These will need to be described as new taxa in appropriate genera if and when names are needed. We hesitate to validate them with an illegitimate generic name, *Le-Ratia*, or a taxonomically inappropriate genus, *Leratiomyces.* The only validly published name for the remaining taxon also excluded from *Leratiomyces* by Bridge et al. (2008), is *Le-Ratia smaragdinus* Pat. ex Sacc. & Trotter.

With regard to "*Le Ratia coccinea*", we note that the publication of new Latin descriptions for several fungi by Wakefield et al. (1916), which were mentioned in a footnote by an editor (H. Schinz) in the publication by Wakefield (1920), is generally overlooked because Latin descriptions are again provided in 1920. Apparently the manuscript for the 1920 publication was available in 1914 but publication was delayed because of World War I [editor's note in Wakefield et al. 1916], and Schinz wished to ensure priority of authorship for the mycologists for the new taxa despite the delay.

Leratiomyces as currently recognized occurs in both the Northern and Southern Hemispheres, encompasses both lamellate and secotioid forms, and inhabits both forested as well as rural and urban habitats. The name *Leratiomyces* has already been adopted for agarics by one author (Kibby 2008).

We offer the following nomenclatural synopsis and new combination as a guide to the names. For more complete taxonomic synonymy, see Bridge et. al. (2008).

Nomenclature

Leratiomyces Bresinsky & Manfr. Binder ex Bridge, Spooner, Beever & D.-C. Park, Mycotaxon 103: 115 (2008)

≡ *Le-Ratia* Pat. ex Sacc. & Trotter, Syll. fung. 21: 468 (1912) nom. illegit., non *Leratia* Broth. & Paris in Brotherus (1909a, b) (Art. 53.1 & 53.3)

= "*Le Ratia* Pat.", Bull. Soc. Mycol. France 23: 52 (1907) non rite publ. (Art. 20.3)

= "*Leratiomyces* Bresinsky & Manfr. Binder", Z. Mykol. 64(1): 80 (1998) non rite publ. (Art. 33.4)

Lectotypus (designated here): ***Leratiomyces similis*** (Pat. ex Sacc. & Trotter) Bresinsky & Manfr. Binder ex Redhead & McNeill, **comb. nov.**

MycoBank mb 512293

Basionym: *Le-Ratia similis* Pat. ex Sacc. & Trotter, Syll. Fung. 21: 468 (1912).

= "*Le Ratia similis* Pat.", Bull. Soc. Mycol. Fr. 23: 52 (1907) non rite publ.(Art. 43.1)

= "*Leratiomyces similis* (Pat.) Bresinsky & Manfr. Binder", Z. Mykol. 64(1): 80 (1998) non rite publ.(Art. 43.1)

Additional included species:

Leratiomyces ceres (Cooke & Massee) Spooner & Bridge
in Bridge et al., Mycotaxon 103: 116 (2008)

Leratiomyces cucullatus (Shope & Seaver) Beever & D.-C. Park
in Bridge et al. Mycotaxon 103: 116 (2008)

Leratiomyces erythrocephalus (Tul. & C. Tul.) Beever & D.-C. Park
in Bridge et al. Mycotaxon 103: 116 (2008)

Leratiomyces magnivelaris (Peck) Bridge & Spooner
in Bridge et al., Mycotaxon 103: 116 (2008)

Leratiomyces percevalii (Berk. & Broome) Bridge & Spooner
in Bridge et al., Mycotaxon 103: 116 (2008)

Leratiomyces squamosus (Pers.) Bridge & Spooner
in Bridge et al., Mycotaxon 103: 116 (2008)

Leratiomyces squamosus* var. *thraustus (Schulzer ex Kalchbr.) Bridge & Spooner
in Bridge et al., Mycotaxon 103: 117 (2008)

Excluded species with a validly published name
(see Bridge et al. 2008):

Le-Ratia smaragdinus Pat. ex Sacc. & Trotter, Syll. fung. 21: 468 (1912)
= "*Le Ratia smaragdinus* Pat.", Bull. Soc. Mycol. Fr. 25: 133 (1909) non rite publ. (Art. 43.1)
= "*Leratiomyces smaragdinus* (Pat.) Bresinsky & Manfr. Binder", Z. Mykol. 64(1): 80 (1998) non rite publ.(Art. 43.1)

Excluded species lacking a validly published name
(see Bridge et al. 2008):

"***Le Ratia atrovirens*** R. Heim", Rev. Mycol. (Paris) 33: 143 (1968) non rite publ. (Art. 36.1, 43.1)
= "*Le Ratia atrovirens* R. Heim", Rev. Mycol. (Paris) 33: 212 (1968) non rite publ. (Art. 43.1)
= "*Leratiomyces atrovirens* (R. Heim) Bresinsky & Manfr. Binder", Z. Mykol. 64(1): 80 (1998) non rite publ.(Art. 33.4, 36.1, 43.1)

Unclassified enigmatic taxon lacking a validly published name:

"***Le Ratia coccinea*** Massee & Wakef." in Wakefield et al., Vierteljahrsschr. Naturf. Ges. Zürich 61: 631 (1916) non rite publ.(Art. 43.1)
= "*Le Ratia coccinea* Massee & Wakef." in Wakefield, Nova Caledonia, Bot. (ed. F. Sarasin, J Roux) 1(2): 104 (1920) non rite publ.(Art. 43.1)
= "*Leratiomyces coccinea* (Massee & Wakef.) Bresinsky & Manfr. Binder", Z. Mykol. 64(1): 80 (1998) non rite publ.(Art. 43.1)

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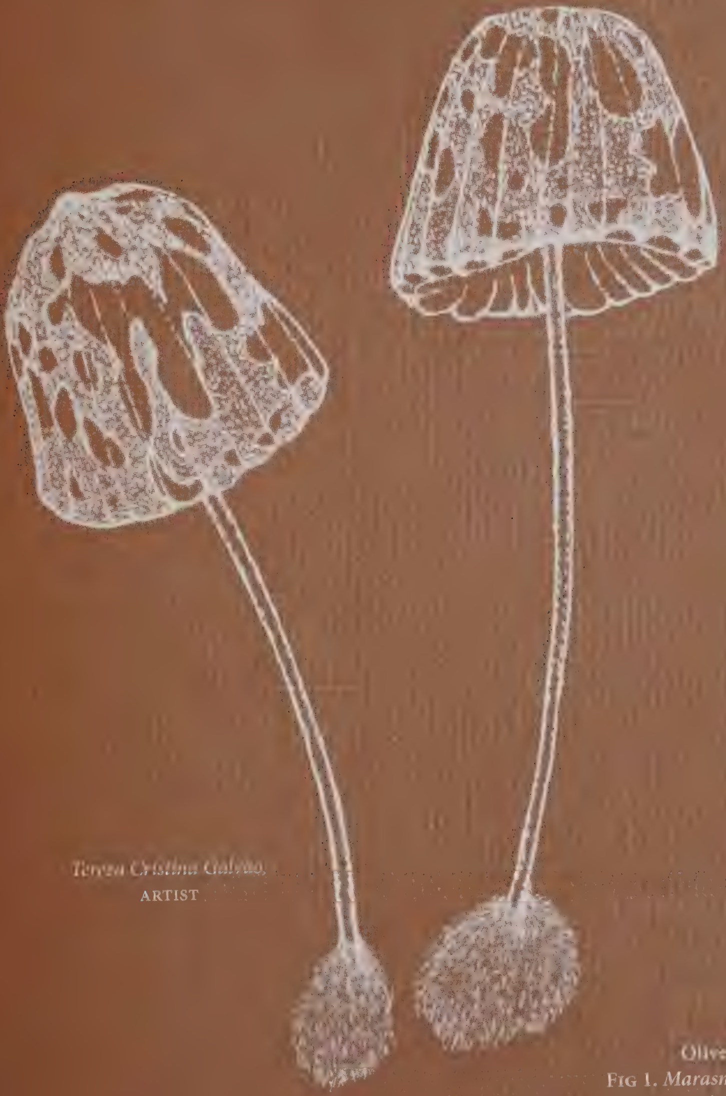

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Oliveira & al.
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(p. 229)

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First record of *Discoxylaria myrmecophila* (*Ascomycotina, Xylariales*) from Veracruz with new reports from Jalisco, Morelos, and Nuevo Leon (Mexico)

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Abstract — Fresh collections of stromata of *Discoxylaria myrmecophila* growing in an ant nest in the State of Veracruz have been studied. Both teleomorph and anamorph stages were found. A description and photographs of the "stroma" are presented. New collections are also reported from the states of Jalisco, Morelos and Nuevo León.

Key words — attine ants, *Hypocreodendron,* distribution

Introduction

Discoxylaria J.C. Lindq. & J.E. Wright is a monotypic genus of *Xylariaceae* in the *Ascomycotina,* with a strong relationship with ant nests of *Acromyrmex* Mayr and *Atta* Fabricius. The teleomorph, described by Lindquist and Wright (1964) from Argentina and Uruguay, formed in the same stroma where the anamorph *Hypocreodendron sanguineum* Henn. also developed. Hennings first described the anamorph stage from Argentina in 1897 (Rogers et al. 1995). In Mexico this fungus was first reported from Morelos by Perez-Silva (1974) and from an unknown locality by Guzmán (1977), in both cases on nests of ants belonging to the genus *Atta.* Rogers et al. (l995), who also studied both teleomorph and anamorph stages from attine nests found in Nuevo León, emended both taxa: *Discoxylaria myrmecophila* and *Hypocreodendron sanguineum.* Recently, Guzmán-Dávalos et al. (2003) reported *D. myrmecophila* from Jalisco. Regarding other fungi associated with *Atta* nests in Mexico, Romero et al. (1987) studied *Phialocladus zsoltii* Kreisel from Veracruz, a fungus previously known only from Cuba (Kreisel, 1972).

In the present paper we discuss the first record of *Discoxylaria myrmecophila* and its anamorph from the State of Veracruz, based on fresh stromata found in a nest of *Atta mexicana* (F. Smith). New herbarium records of *D. myrmecophila* from Jalisco, Morelos, and Nuevo León are also presented.

Materials and methods

Hand sections of stromata mounted in KOH 5% or in Melzer's reagent were made to observe both the teleomorph and anamorph stages. Photographs of fresh stromata as well as microscopic features, were taken.

Results

Discoxylaria myrmecophila J.C. Lindq. & J.E. Wright, Darwiniana 13: 139. 1964; emend. J.D. Rogers, Y.M. Ju & F. San Martín, Mycologia 87: 42. 1995. FIGS. 1-10

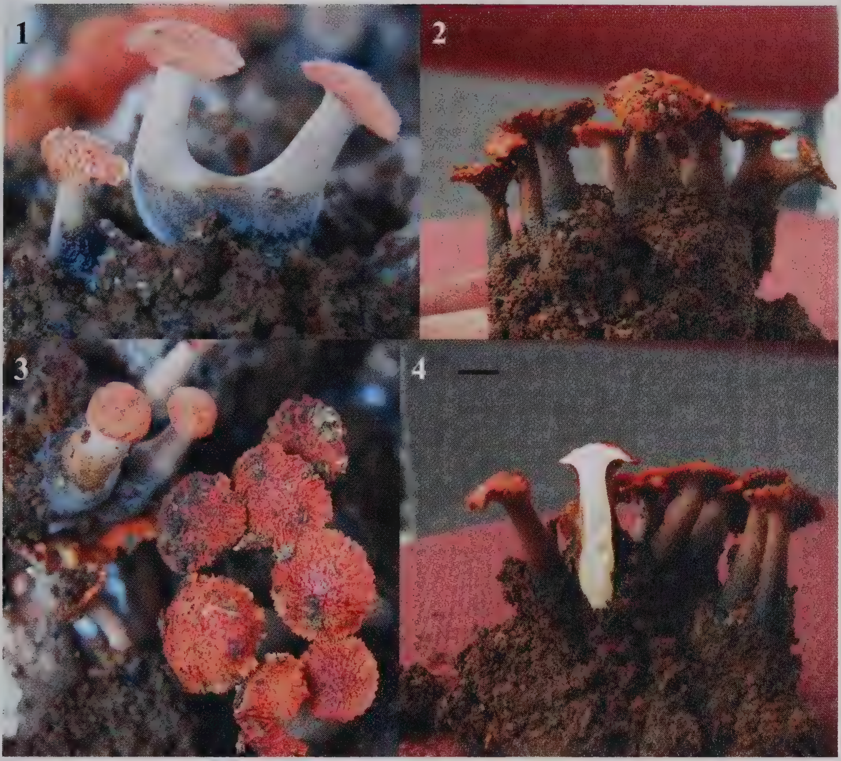
STROMATA 20–35 mm high, erect, simple to branched. The upper part as an enlarged disc, 5–15 mm diam, convex to plane, pitted, veined or alveolate, salmon-orange or orange-reddish. Stipe 10–25 × 2–5 mm, excluding pseudorhiza size, with the base width up to 10 mm, surface white, soon becoming pale grayish-rose to blackish brown from the base to the top, frequently branched, smooth to rough because of the ostioles of the perithecia; pseudorhiza up to 30 mm long, sometimes concrescent, attenuated toward the base, covered with black hyphae, giving a fuzzy aspect. Context subcartilaginous, white. The mycelium mass from the ant nests, has a sweetish smell. Perithecia embedded in the lower part of the stipe and conidiophores developed on the disc.

ASCOSPORES 7–8 × 3–4 µm, ellipsoid-inaequilateral, hyaline to brown or blackish, with one guttule, with an incomplete germ slit and with a hyaline permanent perispore. ASCI 75–90 × 4–6 µm, cylindric, 8-spored, uniseriate, long stipitate, ascal pore 2 × 2 µm, cuboid, blue in Melzer's reagent. PARAPHYSES not seen. Hyphae of the context 3–6 µm wide, septate, thick-walled, dark to light brown. CONIDIOPHORES in synemmata on the disc of the stroma. CONIDIA 8–10 (–12) × 1–2 µm, holoblastic, hyaline, subclavate (slightly wider at one extreme) or cylindric.

HABITAT: on ant-nests of *Atta mexicana*, in public parks or in open places of pine-oak, several types of tropical and subtropical vegetation or in xerophytic zones.

DISTRIBUTION: South America to North America, known from Argentina Uruguay and Mexico.

STUDIED MATERIAL: MEXICO. JALISCO, Municipality of Guadalajara, near Barranca de Huentitlán, Guadalajara Zoo, August 6, 1988, Guerrero 37-A (IBUG); Municipality of Zapopan, University of Guadalajara Sport Club, July 15, 1984, Mendoza s.n. (IBUG, XAL); Bosque La Primavera, July 18, 1985, Guzmán-Dávalos 2058; July 26, 1985, Guzmán-Dávalos 2115 (both IBUG); University of Guadalajara, garden of Instituto de Botánica, October 7, 1986, Guzmán-Dávalos 3624 (IBUG); July 1, 1997, Soto s.n.

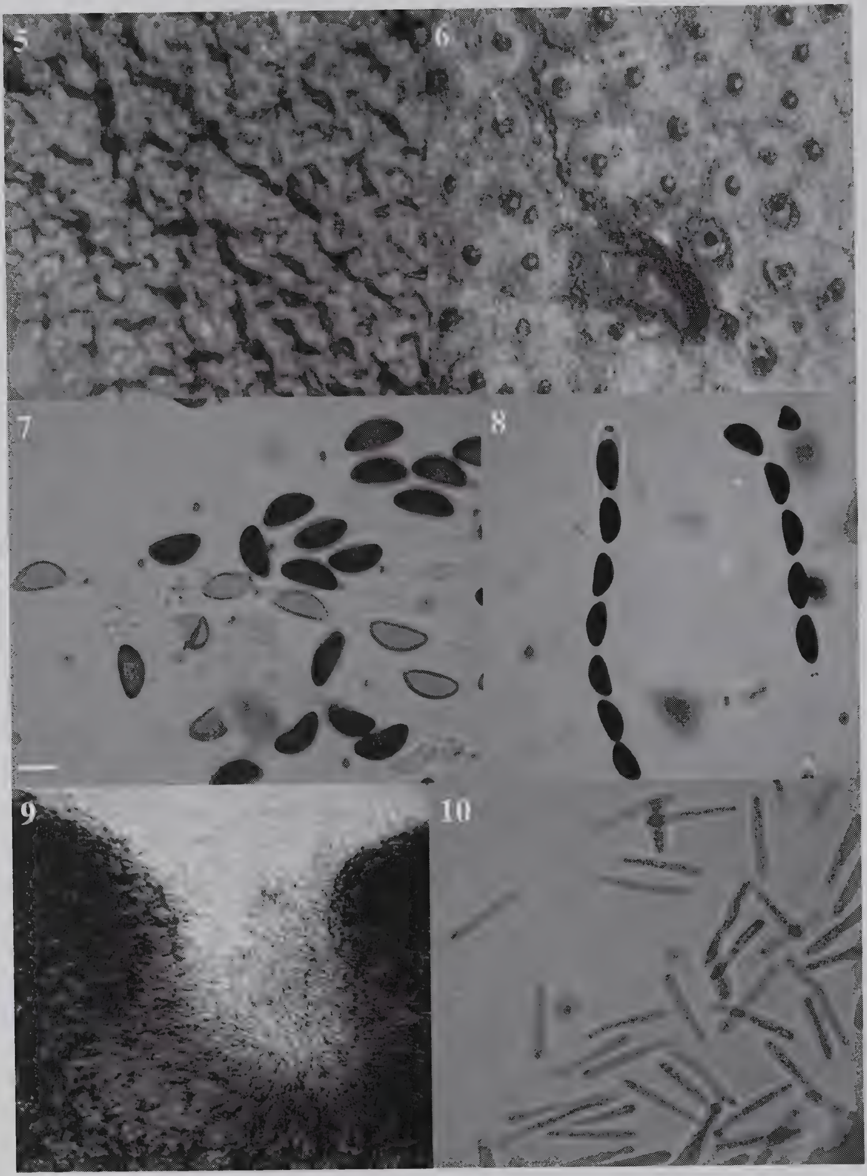


FIGS. 1-4. *Discoxylaria myrmecophila*. 1: Bifurcate stromata; 2: Stromata showing stipe dark color after beginning to dry; 3: Undulating disc surface; 4: Stromata showing the white context (from Lara 202). Scale bar = 5 mm. [Photographs: 1, 3 R. Gaitán; 2, 4 P. Callac.]

(IBUG); S of La Venta del Astillero, Rancho El Paraíso, Carrillo-Reyes 242 (IBUG); Puente Grande, July 5, 1986, Cruz 12 (IBUG). MORELOS, Cuernavaca, July 20, 1979, López 586 (XAL); Municipality of Tepoztlán, S of Santo Domingo, October 12, 1990, Pérez de la Rosa s.n. (IBUG). NUEVO LEÓN, Municipality of Guadalupe, La Pastora, June, 1980, De la Garza s.n.; May 9, 1979, García s. n. (both in XAL). VERACRUZ, Municipality of Ixtaczoquitlán, Barranca de San Miguel, without date, Gómez s.n. (XAL); Municipality of Xalapa, Xalapa city, Los Lagos Park, Nov. 23, 2007, Lara 202; Nov. 25, 2007, Lara 208 (both XAL).

Discussion

With the exception of one collection (López 586, XAL), all the studied materials lacked ascospores, although closed, empty black ostioles of perithecia were observed on the stipe. According to Rogers et al. (1995), absence of ascospores from the stroma appears to be common in *Discoxylaria myrmecophila*. Since



Figs. 5-10. *Discoxylaria myrmecophila* and *Hypocreodendron sanguineum*. 5: Undulate surface of the disc of the stroma; 6: Perithecial ostioles on the stipe surface; 7: Inaequilateral ascospores; 8: Asci showing ascal pore; 9: Tranverse view of *H. sanguineum* showing depression that forms the undulate surface of the disc; 10: Conidia [detail] (figs. 5, 9, 10: from Lara 202; figs. 6-8: from López 586. Scale bars: 5&6 = 1 mm; 7, 8 & 10 = 10 µm; 9 = 25 µm [Photographs: R. Medel.]

teleomorph and anamorph appear together within the same stroma, Rogers et al. (1995) suggest that the anamorph probably appears before the teleomorph, although the perithecia lack ascospores. Interestingly, the sweetish smell associated with the nest's mycelial mass in Lara 208 was first recorded by Hennings, who studied the anamorph in culture in 1897 (Rogers et al. 1995). *Discoxylaria myrmecophila* displays a disjunct geographic distribution and has been recorded only from Argentina, Uruguay and Mexico. Surprisingly, Dennis (1979) did not record this species, and even the fungal databases of Costa Rica (atta.inbio.ac.cr/), Ecuador (www.mycokey.com/Ecuador) and the Caribbean (www.biodiversity.org) do not mention this fungus. Despite more than 50 years of field mycological work in Mexico, we have only a few collections of this fungus. Given that this is the first record from Veracruz, where so much mycological research has been conducted, we consider *Discoxylaria myrmecophila* a "rare" fungus. However, in view of the broad distribution of ants belonging to the *Formicidae* tribe *Attini* throughout the Americas recorded by Kempf (1972) from the southern United States to Central America (Kempf 1972) and by Flores-Maldonado et al. (1999) from Tamaulipas, Mexico, we expect that this fungus has a wide distribution in subtropical America.

Acknowledgments

We express our thanks to Dr. Laura Guzmán-Dávalos (Universidad de Guadalajara) and Dr. Richard Hanlin (University of Georgia) for reviewing this paper. We also thank Dr. Jorge Valenzuela (Instituto de Ecología) for providing information on the ants and their geographical distribution and especially acknowledge Juan Lara Carmona (Instituto de Ecología) for fresh collections and Rigoberto Gaitán (Instituto de Ecologia) and Phillipe Callac (Institute Natinale de la Recherche Agronomique, Bordeaux, France) for the color photographs. Laura Guzmán-Dávalos is also thanked for the loan of *Discoxylaria myrmecophila* collections from IBUG.

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Phallus luteus comb. nov., a new taxonomic treatment of a tropical phalloid fungus

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Abstract — A new combination, *Phallus luteus* is proposed for a tropical phalloid fungus, *Dictyophora indusiata* f. *lutea*. Macro- and microscopic characteristics are described and illustrated based on Japanese specimens.

Key words — gasteromycetes, Japan, *Phallaceae*

Introduction

Phallus Junius ex L. is a gasteromycetous fungal genus of *Phallaceae*, *Phallales* that includes morphologically variable species. Hitherto, 25 taxa of this genus have been recognized (Calonge 2005). According to Kreisel (1996), important morphological characteristics for taxonomy are: 1) shape and surface configuration of the pileus; 2) presence or absence of yellow to red pigments (carotenoids) in pileus, receptacle and indusium; and 3) presence or absence of pinkish to purple discoloration in peridium and rhizomorphs. The presence of an indusium has been emphasized as an important taxonomic characteristic by several authors (Fischer 1933, Kobayasi 1938, Pilát 1958, Liu et al. 2005) so that the genus *Dictyophora* Desv. has been accepted as independent in the past based on its presence. However, Andersson (1989), Kreisel (1996), Calonge (2005), Sarasini (2005) and Baseia et al. (2006) recognized close morphological relationships between phalloid species with and without indusium, and they noted that presence of an indusium is an unstable character for taxonomy. Therefore, *Dictyophora* is currently put into synonymy with *Phallus*, following the above authors.

Three *Phallus* taxa with indusia — i.e. *P. indusiatus* Vent., *P. impudicus* var. *pseudoduplicatus* O. Andersson, *P. rubrovolvatus* (M. Zang et al.) Kreisel — have been reported from Japan (Kobayasi 1938, Ito 1959, Yoshimi & Hongo

1989, Kasuya et al. 2007). Moreover, another with a yellow pileus and an indusium — *Dictyophora indusiata* f. *lutea* (≡ *D. lutea*) — has been recorded from western Japan (Kobayasi 1938, 1942, 1965a, b; Ito 1959; Yoshimi & Hongo 1989; Yamamoto & Yamamoto 2007), China (Liou & Hwang 1936, Liu et al. 2005), Korea (Kobayasi 1965a) and Mexico (Guzmán et al. 1990). Kreisel (1996) and Kasuya et al. (2007) treated this fungus as "*Phallus* sp." and noted that further study was needed to clarify its taxonomic position. Below I describe and illustrate Japanese specimens of this fungus and transfer the species formally to *Phallus*.

Materials and methods

The specimens examined in this study are deposited in the herbaria of National Museum of Nature and Science, Tsukuba (TNS), and Miyazaki Prefectural Museum, Miyazaki (MPM). Macroscopic characters were described by observations on dried or fresh materials. For light microscopic observations, free hand sections of dried or fresh specimens were mounted in water, 3% or 5% (w/v) KOH and 30% ethanol solution on glass slides. More than forty randomly selected basidiospores were measured under a light microscope at 1000× magnification.

Taxonomy

Phallus luteus (Liou & L. Hwang) T. Kasuya, **comb. nov.** FIGURES 1–2

MYCOBANK MB 512085

Basionym: *Dictyophora lutea* Liou & L. Hwang, Chinese J. Bot. 1: 89 (1936).

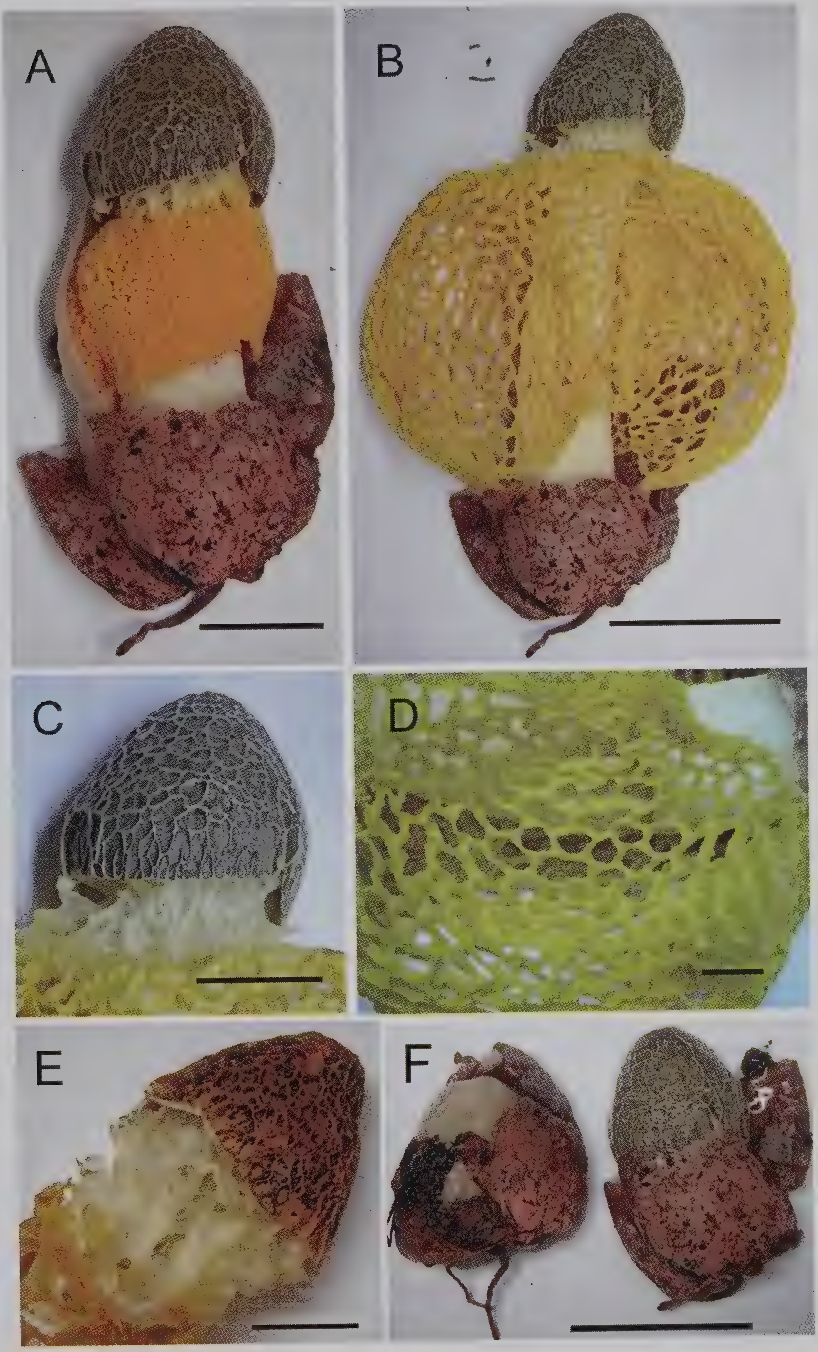
≡ *Dictyophora indusiata* f. *lutea* (Liou & L. Hwang) Kobayasi, J. Jap. Bot. 40: 179 (1965).

= *Dictyophora indusiata* f. *aurantiaca* Kobayasi, Nova Flora Japonica 2: 83 (1938).

= *Phallus industiatus* f. *citrinus* K. Das, S.K. Singh & Calonge, Bol. Soc. Micol. Madrid 31: 136 (2007).

EGG subglobose to ovoid, 30-55 × 30-60 mm, hypogeous or subhypogeous when young, later epigeal, pale pink to reddish purple, with long, branched, pink to reddish purple rhizomorphs up to 150 mm long. PERIDIUM three-layered: exoperidium papery, persistent, pale pink to reddish purple, surface smooth but slightly gyrose near the base; mesoperidium gelatinous, viscous, thick, hyaline, pale pink to reddish purple; endoperidium membranous to slightly fibrous, very thin, evanescent, whitish, covering upper surface of gleba.

FIG. 1. *Phallus luteus* (from TNS-F-18157): A: expanding basidioma, B: mature basidioma, C: pileus with gleba, D: indusium, E: pileus without gleba, F: two basidiomata one of them expanding with reddish purple peridium. Bars: A, C = 20 mm; B = 45 mm; D = 5 mm; E = 10 mm; F = 18 mm.


A
B
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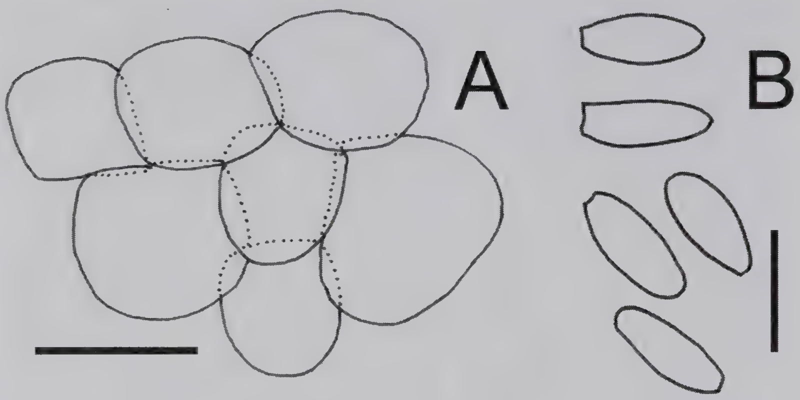

Fig. 2. *Phallus luteus* (from TNS-F-18159)
A: Pseudoparenchymatous cells of the receptacle, B: basidiospores.
Bars: A = 20 µm; B = 4 µm.

Mature basidiomata 85–240 mm tall, composed of a receptacle, a pileus covered with a gleba and an indusium. Receptacle forming a pseudostipe, 70–220 mm tall, 15–25 mm diam. at apex, cylindrical, subfusoid or tapering toward the base, spongy, hollow, surface reticulate with polygonal depressions, white, cream to pale yellow, with pink to reddish purple peridium at the base. Pileus conical to slightly campanulate, apex somewhat conical, truncate with a whitish disc at the centre, 25–40 mm tall, 26–38 mm diam. at lower margin, surface strongly reticulate, pale yellow to yellowish orange, covered with gleba; meshes deep, polygonal to rounded, 2–5 mm diam. Gleba mucous, olivaceous brown to greenish black, with foetid odor. Indusium 60–160 mm long, papery, fragile when dried, margin entire; dissetiment narrow, yellow to yellowish orange; meshes polygonal to rounded, 2–7 mm diam. Exoperidium divided into two layers; outer one up to 250–500 µm thick, composed of filamentous hyphae, 5–15 µm diam., elongate, interwoven, septate, thick-walled, hyaline, pale brown to purplish brown, with clamp-connections; inner one up to 100–250 µm thick, composed of filamentous hyphae 2–4 µm diam., elongate, subparallel, gelatinous, septate, thick-walled, hyaline, with clamp-connections. Receptacle consists of pseudoparenchymatous cells 5–43 µm diam., globose to subglobose, thin-walled. Basidia not observed. Basidiospores broadly ellipsoid to cylindric, 3–4 × 1.5–2 µm, smooth, hyaline, thin-walled, often truncate at base.

Habitat — On the ground or humus in evergreen woods and bamboo groves, especially under *Cryptomeria japonica*, *Phyllostachys pubescens, Quercus* spp. or *Castanopsis* spp.

Distribution — Japan, China, Korea, India, tropical America (Mexico).

Japanese name — Usuki-kinugasa-take (Kobayasi 1938).

Specimens examined — **JAPAN. Hiroshima Prefecture,** Hiroshima-shi, Asakita-ku, Kuji, on the ground under *Cryptomeria japonica* woods, 23 July 2007, M. Yamate (TNS-F-18157); **Yamaguchi Prefecture,** Iwakuni-shi, Misho, on the ground under *Phyllostachys pubescens* grove, 14 July 2008, K. Katumoto (TNS-F-18610); **Kochi Prefecture,** Takaoka-gun, Sakawa-cho, Mt. Kokuzo, on the ground under *C. japonica* woods, 4 July 2007, Y. Yamamoto (TNS-F-18158); Kami-shi, Kahoku-cho, Ioroi, on the ground under *C. japonica* woods, 7 July 2007, R. Yamamoto (TNS-F-18159); **Miyazaki Prefecture,** Higashi-usuki-gun, Morotsuka-son, 21 September 1976, Y. Doi (TNS-F-227340); Higashi-usuki-gun, Saigo-son, Ohara, on the ground under *Quercus* spp., 10 October 1998, S. Kurogi, B-E-27 (MPM); Nishi-morogata-gun, Takahara-cho, Oike, on the ground under evergreen forest, July 1999, S. Kurogi, B-E-2449 (MPM); Higashi-morogata-gun, Kunitomi-cho, Kusumi, on the ground under evergreen forest, 11 October 1999, S. Kurogi, B-E-4473 (MPM); Kobayashi-shi, Kiuragi, 12 October 1999, S. Kurogi, B-E-2446 (MPM); Higashi-morogata-gun, Aya-cho, Kawanaka, on the ground under evergreen forest, 19 September 2000, S. Kurogi, B-E-509 (MPM); Nobeoka-shi, Mt. Mukabaki, on the ground under evergreen forest, July 12 2003, S. Kurogi, B-E-2129 (MPM); Miyazaki-shi, Mt. Boroishi, on the ground under evergreen forest, 10 September 2006, S. Morimoto, B-E-4099 (MPM).

Discussion

Morphological characters of the specimens examined agree well with the previous descriptions of the present fungus (Liou & Hwang 1936, Kobayasi 1938, 1942, 1965a, b, Ito 1959, Yoshimi & Hongo 1989, Guzmán et al. 1990, Liu et al. 2005, Yamamoto & Yamamoto 2007). This fungus was defined by a yellowish reticulate pileus, yellow indusium, and pale pink to reddish purple peridium with rhizomorphs. These morphological characteristics suggest its placement in *Phallus* subgen. *Phallus* sect. *Flavophallus* Kreisel (Kreisel 1996). It clearly differs from *P. indusiatus* (≡ *D. indusiata*) in its yellow pileus and indusium, and pale pink to reddish purple peridium with rhizomorphs. Therefore, *D. indusiata* f. *lutea* is accepted as an independent species, *P. luteus*.

The recently described Indian fungus, *P. indusiatus* f. *citrinus* (Das et al. 2007), is morphologically very similar to *P. luteus* in having yellow pileus and indusium, vinaceous to dark vinaceous peridium. Original description and color figures of *P. indusiatus* f. *citrinus* (Das et al. 2007) represent well the present fungus in both macroscopic and microscopic features. Therefore, I conclude they are identical. *Phallus luteus* having priority over *P. indusiatus* f. *citrinus*, the name should be adopted as the correct one for the present fungus (Art. 11.4, ICBN Vienna Code).

There are seven other known *Phallus* species in section *Flavophallus* (Kreisel 1996). Among them, *P. callichrous* (Möller) Lloyd, *P. multicolor* (Berk. & Broome) Cooke, and *P. cinnabarinus* (W.S. Lee) Kreisel are morphologically similar to *P. luteus* in possession of indusium and purplish eggs. However, its whitish indusium clearly distinguishes *P. callichrous* (Kobayasi 1942). *Phallus multicolor* is also distinguishable from *P. luteus* by its orange, pink to red pileus and indusium and slightly longer (3.5–4.5 × 1.5–2 µm; Cunningham 1944) basidiospores. Further, *P. cinnabarinus* is clearly different from *P. luteus* because the former has a cinnabar-red to brilliant red pileus and indusium (Lee 1957). The four other species in sect. *Flavophallus* — *P. flavocostatus* Kreisel, *P. tenuis* (E. Fisch.) Kuntze, *P. sulphureus* Lohwag and *P. formosanus* Kobayasi — differ from *P. luteus* in their white to yellowish peridium, yellow to pink receptacles and the absence of an indusium (Kobayasi 1938, Li et al. 2004, 2005).

Phallus tenuissimus T. H. Li et al., recently described from China (Li et al. 2005), also has a yellow, reticulate pileus and a pale yellow receptacle with a white to yellowish peridium. Although *P. tenuissimus* is probably placed in section *Flavophallus*, it is clearly distinguished from *P. luteus* by its peridium colour and the absence of an indusium.

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MYCOTAXON

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Conidial fungi from semi-arid Caatinga biome of Brazil. New and interesting *Dictyochaeta* species

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Abstract – During preparation of an inventory of dematiaceous hyphomycetes from dead plant material in six areas of extreme biological importance of Caatinga biome, some species of *Dictyochaeta* were found. *Dictyochaeta caatingae* and *D. intermedia* are proposed as new species. *Dictyochaeta britannica*, *D. microcylindrospora*, *D. obesispora*, and *D. setosa* are new records to the American continent, while *D. heteroderae* is new to the neotropics and *D. triseptata* is new to Brazil. These species are described, discussed and illustrated. A key to known species collected in Brazil is provided.

Key words – litter fungi, systematic

Introduction

The genus *Dictyochaeta* was proposed by Spegazzini (1923), with *D. fuegiana* as the type species. An historical review of related genera, such as *Codinaea* Maire and *Dictyochaetopsis* Aramb. & Cabello were made by Kuthubutheen & Nawawi (1991a) and Whitton et al. (2000). More recently, two additional species have been described, *D. multifimbriata* R. Kirschner & Chee J. Chen, with reniform, 0-septate conidia, and *D. curvispora* L. Cai, et al., with curved, asetulate conidia (Kirschner & Chen 2002, Cai et al. 2004).

Six species of *Dictyochaeta* occurring on decaying plant material in Brazil have hitherto been collected: *D. eucalypti* (B. Sutton & Hodges) Whitton et al., *D. septata* (B. Sutton & Hodges) Whitton et al., *D. simplex* (as *Codinaea*, Sutton & Hodges 1975), *D. fertilis* (Grandi 1990), *D. novae-guineensis* (Grandi 1998) and *D. pluriguttulata* (Barbosa et al. 2007).

Materials and methods

The semi-arid Caatinga biome was described in previous papers (Cruz et al. 2007a,b, Marques et al. 2007). Samples of plant litter were placed in separate paper bags and taken to the laboratory. The litter was then incubated at 25° C in Petri dishes, within moist chambers, consisting of plastic boxes (50 L capacity) containing 200 ml of sterile water plus 2 ml of glycerol (Castañeda-Ruiz 2005). The samples were examined at regular intervals for the presence of microfungi. Mounts were prepared in polyvinyl alcohol-glycerol (8.0 g in 100 ml of water, plus 5 ml of glycerol) and measurements made at a magnification of ×1000.

Taxonomic part

Dictyochaeta caatingae A.C. Cruz & Gusmão **anam. sp. nov.** FIGS 1–2
MycoBank MB511940

COLONIAE effusae, brunneae. MYCELIUM plerumque in substrato immersum. HYPHAE septate, ramosae, laeviae, brunneae. SETAE solitariae vel 2–3 fasciculatae, erectae, rectae vel flexuosae, 9–15-septatae, laeves, subulatae, basim versus atrobrunneae, apicem versus brunneae vel pallide brunneae, 160–295 × 4.5–6 µm, ad basim dilatata 7.5–9.5 µm latae. CONIDIOPHORA solitaria vel 2–5 fasciculata, macronematosa, mononematosa, erecta, recta vel flexuosa, 1-4-septata, simplicia, laevia, basim versus pallide brunnea, apicem versus subhyalina, 37–89 × 3.5–6 µm. CELLULAE CONIDIOGENAE monophialidicae, raro polyphialidicae in conidiophoris incorporatae, determinatae, raro cum proliferationibus sympodialis, cylindricae, pallide brunneae vel hyalinae, 12–48 × 3.5–6 µm. CONIDIA 3-septata, plus minusve falcata, laevia, hyalina, in massam mucosum, 27–35.5 × 3.3–5.5 µm; plerumque utrinque setulis simplicibus, 0.5–2.5 µm longis praedita. TELEOMORPHOSIS ignota.

HOLOTYPUS: HUEFS 129377. ***BRAZIL. BAHIA: Senhor do Bonfim****, in foliis angiospermae ignotae, 10.X.2006, coll. A.C.R. Cruz.*

ETYMOLOGY: *caatingae*, in reference to the Caatinga biome.

COLONY effuse, brown. MYCELIUM immersed in substrate. HYPHAE septate, branched, smooth, brown. SETAE solitary or in groups of 2–3, erect, straight or flexuous, 9–15-septate, smooth, subulate, brown to pale brown, 160–295 × 4.5–6 µm; basal cell swollen to 7.5–9.5 µm. CONIDIOPHORES solitary or in groups of 2–5, macronematous, mononematous, straight or flexuous, 1–4-septate, simple, smooth, brown to subhyaline at apex, 37–89 × 3.5–6 µm. CONIDIOGENOUS CELLS monophialidic, determinate or rarely polyphialidic, then sympodial, integrated, cylindrical, pale brown to hyaline, 12–48 × 3.5–6 µm; collarette, 1–3 × 1–2 µm. CONIDIA 3-septate, falcate to allantoid, smooth, hyaline, in slimy mass, 27–35.5 × 3.3–5.5 µm. SETULAE filiform 1 or 2, differing in number at each end, 0.5–2.5 µm long. TELEOMORPH unknown.

COMMENTS: *Dictyochaeta matsushimae* (Hewings & J.L. Crane) Whitton et al., is the only species that has 3-septate conidia and sterile setae. However, the conidia of *D. matsushimae* are shorter, although the setulae are longer, than those of *D. caatingae*. *D. macrospora* Kuthub. & Nawawi (Kuthubutheen & Nawawi 1991b) and *D. triseptata* (Castañeda-Ruiz 1986) are similar to the proposed new species, but possess consistently polyphialidic conidiophores and longer conidia and setulae (Table 1).

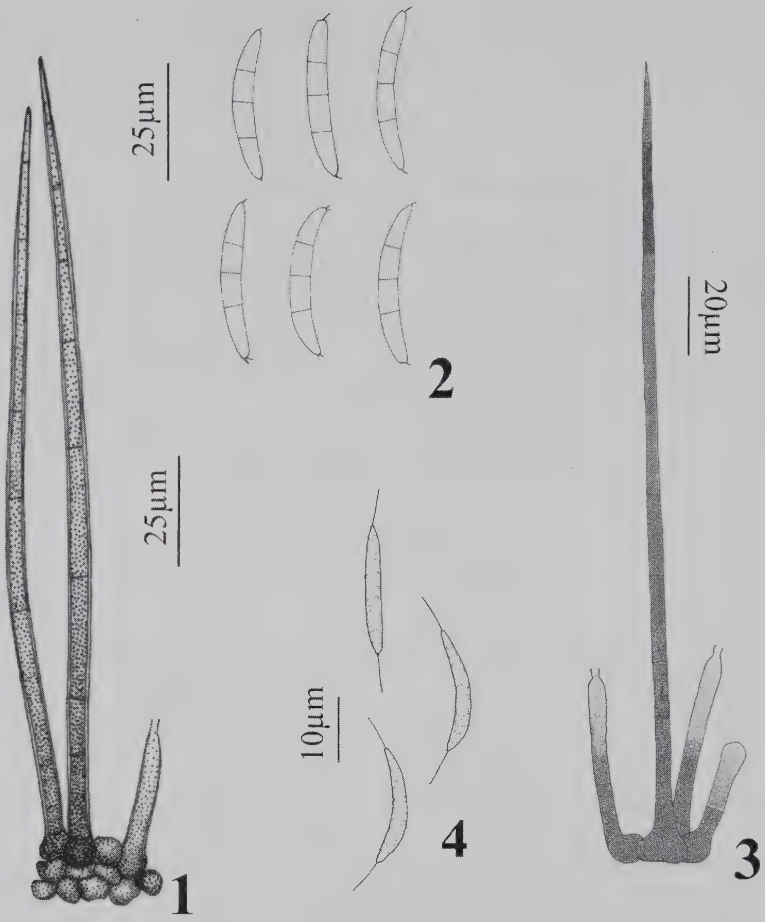
TABLE 1. Comparison of *Dictyochaeta* species morphologically similar to *D. caatingae*

SPECIES	SETAE	CONIDIOGENESIS	CONIDIA		
			SEPTA (#)	SIZE (µm)	SETULAE (µm)
D. brevisetula	Present	polyphialidic	1–3	21–24.5 × 3–3.7	1.4–2.7
D. caatingae	Present	monophialidic/ polyphialidic	3	27–35.5 × 3.3–5.5	0.5–2.5
D. dimorpha	Absent	monophialidic/ polyphialidic	0 3	10–18 × 1–2 22–28 × 7–8	absent 5–6
D. macrospora	Absent	polyphialidic	3	38–47 × 5–7	22–30
D. matsushimae	Present	polyphialidic	(1–2)–3	20–27 × 3.3–5.4	5.5–7.8
D. septata	Present	polyphialidic	1–3	(14.5–)17–23 × 2	5.5–10
D. triseptata	Absent	polyphialidic	3	21–30 × 6–7.5	3–6
D. variabilis	Absent	monophialidic	1–3	30–40 × 4.5–5.7	17–23

Dictyochaeta intermedia Gusmão & S.M. Leão, **anam. sp. nov.** FIGS 3–4

MYCOBANK MB511941

> COLONIAE *effusae, brunneae.* MYCELIUM *plerumque in substrato immersum.* HYPHAE *septate, ramosae, laeviae, brunneae.* SETAE *solitariae, erectae, rectae, 9–15-septatae, laeves, subulatae, basin versus atrobrunneae, apicem versus brunneae vel pallide brunneae, 150–354 × 6–9 µm; cellula penultima fusca, 25—47.5 µm longa.* CONIDIOPHORA *solitaria vel 2–5 fasciculata, macronematosa, mononematosa, erecta, recta vel flexuosa, 2-7-septata, simplicia, laevia, basim versus pallide brunnea, apicem versus subhyalina, 30–90 × 3–6 µm.* CELLULAE CONIDIOGENAE *monophialidicae, in conidiophoris incorporatae, determinatae, cylindricae, cum collarulo distincte, 1.8–2.4 µm longa, pallide brunneae versus hyalinae.* CONIDIA *0-septata, falcata, laevia, pluriguttulata, hyalina, in massam mucosum, 18–25 × 1.5–4 µm; plerumque utrinque setulis simplicibus, 3.5–6.5 µm longis praedita.* TELEOMORPHOSIS *ignota.*
>
> HOLOTYPUS: *HUEFS 114791.* **BRAZIL. BAHIA:** ***Senhor do Bonfim,*** *in foliis angiospermae ignotae, 10.X.2006, coll. S.M. Leão-Ferreira.*
>
> ETYMOLOGY: *intermedia,* in reference to position between two previous described species.



Figs 1-2. *Dictyochaeta caatingae*. 1. Setae and conidiophore. 2. Conidia.
Figs 3-4. *Dictyochaeta intermedia*. 3. Seta and conidiophores. 4. Conidia.

Colony effuse, brown. Mycelium immersed in substrate. Hyphae septate, branched, smooth, brown. Setae solitary, erect, straight, 9–15-septate, smooth, brown at the base, brown to pale brown at apex, 150–354 × 6–9 µm; penultimate cell dark brown, 25–47.5 µm long. Conidiophores arising solitary or in groups of 2–5, associated with base of setae, macronematous, mononematous, erect, straight or flexuose, 2–7-septate, simple, smooth, pale brown at the bases, subhyaline at apex, 30–90 × 3–6 µm. Conidiogenous cells monophialidic, determinate, integrated, cylindrical, conspicuous collarettes 1.8–2.4 µm long, pale brown to hyaline. Conidia 0-septate, falcate, simple, smooth, pluriguttulate, in slimy mass, hyaline, 18–25 × 1.5–4 µm. SETULAE simple at each end, 3.5–6.5 µm long. TELEOMORPH unknown.

COMMENTS: The combination of characters including setae with one cell darker and conidia pluriguttulate are found only in three species of *Dictyochaeta* hitherto described: *Dictyochaeta* anamorph of *Chaetosphaeria pulchriseta* S. Hughes et al. (Hughes & Kendrick 1968), *D. pluriguttulata* and *D. vittata* Kuthub. & Nawawi (Kuthubutheen & Nawawi 1991b). The inconspicuous setulae and asymmetrical morphology of conidia in *D. pluriguttulata* are sufficient to separate it from *D. intermedia*. The new species is most similar to *Dictyochaeta* anamorph of *Chaetosphaeria pulchriseta* and *D. vittata* in the general morphology but the size of conidia and setulae are intermediate between the two known species (Table 2).

TABLE 2. Comparison of *Dictyochaeta* species morphologically similar to *D. intermedia*

SPECIES	SETAE (µm)		CONIDIA (µm)	
	SIZE	DARK CELL	SIZE	SETULAE
D. intermedia	150–354 × 6–9	25–47.5	18–21 × 1.5–2.5	3.5–6.5
D. pluriguttulata	up to 220 × 5–7	20–50	20–27 × 2–2.7	inconspicuous
D. anamorph of *Chaetosphaeria pulchriseta*	up to 360 × 5.6–7	36–81	23–29 × 2.4–3	up to 1.8
D. vittata	up to 350 × 6–8	20–35	25–32 × 2.5–3	10–12

Dictyochaeta britannica (M.B. Ellis) Whitton, McKenzie & K.D. Hyde, Fungal Diversity 4: 137. 2000. FIGS 5–6

Bas.: *Codinaea britannica* M.B. Ellis, More Dematiaceous Hyphomycetes: 472. 1976.

Syn.: *Menispora britannica* (M.B. Ellis) P.M. Kirk, Mycotaxon 23: 334. 1985.

SETAE solitary, erect, straight or flexuous, septate, subulate, smooth, brown to subhyaline, 60–345 × 3–6 µm; apex acerose to rounded. CONIDIOPHORES macronematous, mononematous, solitary or in groups of 2–5 arising from the base of setae, straight or flexuous, septate, simple, smooth, brown to pale brown, 49.5–79.5 × 3–4.5 µm. CONIDIOGENOUS CELLS monophialidic or polyphialidic, integrated, sympodially proliferating, conspicuous collarettes, pale brown. CONIDIA solitary, 0-septate, lunate, simple, smooth, in slimy mass, hyaline, 12.5–19 × 1–2.5 µm. SETULAE filiform on each end, 7–10.5 µm.

SPECIMENS EXAMINED: **BRAZIL. BAHIA: Jeremoabo**, "Mata das Pororocas", on decaying bark, 17/I/2007, A.C.R. Cruz, HUEFS 129375; **Paulo Afonso,** on dead leaves of unidentified dicotyledon, 31/I/2007, A.C.R. Cruz, HUEFS 129376.

KNOWN DISTRIBUTION: United Kingdown, Kenya (Ellis 1976, Kirk 1985).

COMMENTS: *Dictyochaeta britannica* is similar to *D. australiensis* (B. Sutton) Whitton et al., but has wider conidia and possesses a radially lobed cell at the base of the setae. The dimensions of conidia are consistent with the descriptions given by Ellis (1976) and Kirk (1985); however, the setulae of the examined specimens are longer than the material studied by Kirk (1985). *D. britannica* is recorded for the first time for the American continent.

Dictyochaeta heteroderae (Morgan-Jones) Carris & Glawe,
Mycotaxon 33: 23. 1988. FIGS 7–8
Bas.: *Codinaea heteroderae* Morgan-Jones, Mycotaxon 14(1): 175. 1982.

SETAE absent. CONIDIOPHORES macronematous, mononematous, solitary, straight or slightly flexuous, septate, simple, smooth, pale brown to brown, paler towards the apex, 75–195 × 3–3.5 µm. CONIDIOGENOUS CELLS monophialidic or polyphialidic, integrated, terminal or intercalary, percurrently proliferating, conspicuous collarettes, pale brown, 20–27.5 × 2.0–2.5 µm. CONIDIA solitary, 0-septate, ellipsoid to allantoid, gently curved, simple, smooth, in slimy mass, hyaline, 6–9.5 × 1–2.4 µm. SETULAE absent.

SPECIMEN EXAMINED: **BRAZIL. BAHIA: Santa Terezinha**, Serra da Jibóia, on decaying twig, 10/I/2008, F.R. Barbosa, HUEFS 122284.

KNOWN DISTRIBUTION: Australia (Matsushima 1989), United States of America (Morgan-Jones 1982).

COMMENTS: *Dictyochaeta heteroderae* resembles *D. coffeae* (Maggi & Persiani) Whitton et al. by the percurrent proliferation of the conidiogenous cells but differs mainly in the absence of setulae at the end of conidia (Maggi & Persiani 1984). The specimen examined has conidia smaller than the material studied by Morgan-Jones (1982) (9–13 × 3–4 µm) and Matsushima (1989) (10–16 × 3–5 µm). The species is recorded for the first time for the neotropics.

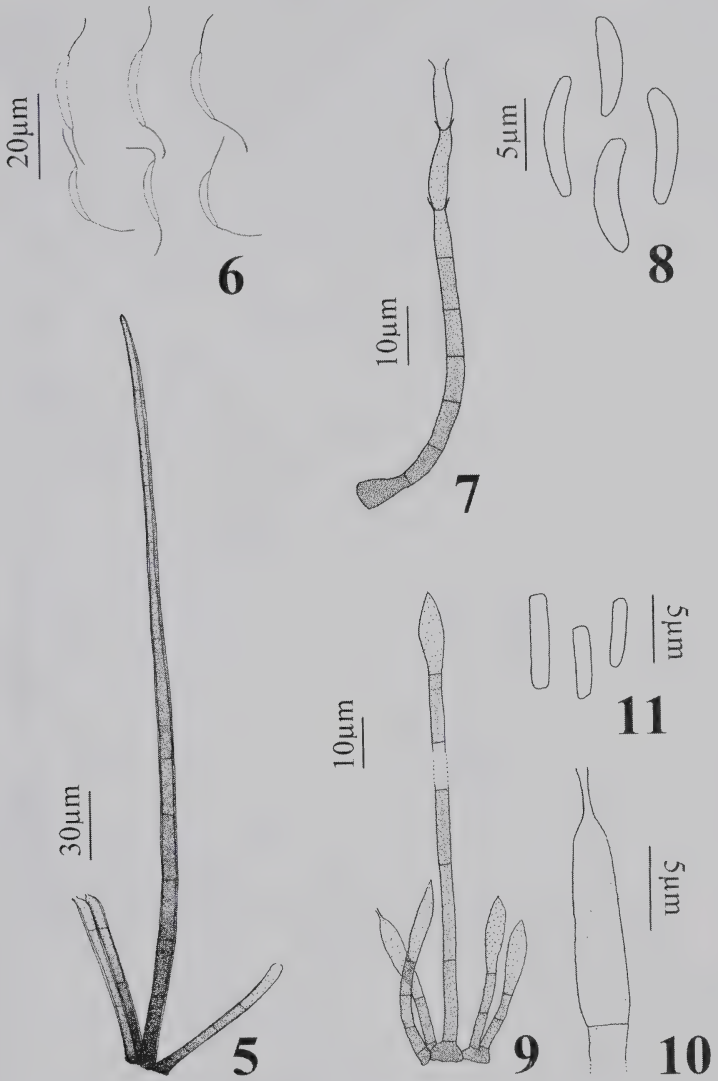
Dictyochaeta microcylindrospora Whitton, McKenzie & K.D. Hyde,
Fungal Diversity 4: 141. 2000. **Figs 9–11**

SETOSE CONIDIOPHORES, solitary, erect, straight, septate, smooth, brown at the base, paler at apex, 93–123 × 2.5–3 µm. CONIDIOPHORES macronematous, mononematous, arranged in groups of 1–4 arising from the base of setae, straight, septate, simple, smooth, pale brown, 32–37.5 × 1.5–2.5 µm. CONIDIOGNEOUS CELLS monophialidic, integrated, terminal, determinate, pale brown; collarettes conspicuous, 2.4–3 µm long. CONIDIA solitary, 0-septate, cylindrical, simple, smooth, in slimy mass, hyaline, 4.2–7.8 × 1–1.2 µm; SETULAE absent.

SPECIMEN EXAMINED: **BRAZIL. BAHIA: Santa Terezinha**, Serra da Jibóia, on dead leaves of Clusia melchiorii Gleason, 09/II/2006, F.R. Barbosa, HUEFS 123308.

KNOWN DISTRIBUTION: China (Whitton et al. 2000).

COMMENTS: *Dictyochaeta microcylindrospora* is closely to *D. cylindrospora* (Morgan-Jones & E.G. Ingram) Whitton et al. but differs by the smaller conidia. The species was recently found on dead leaves of *Pandanus furcatus* Roxb.



Figs 5-6. *Dictyochaeta britannica*. 5. Seta and conidiophores. 6. Conidia.
Figs 7-8. *Dictyochaeta heteroderae*. 7. Conidiophore. 8. Conidia.
Figs 9-11. *D. microcylindrospora*. 9. Setose conidiophore and conidiophores.
10. Detail of conidiogenous cell. 11. Conidia.

(Whitton et al. 2000). The species is recorded for the first time for the American continent.

Dictyochaeta obesispora (S. Hughes & W.B. Kendr.) Whitton, McKenzie & K.D. Hyde, Fungal Diversity 4: 145. 2000. Figs 12–13

Bas.: *Codinaea obesispora* S. Hughes & W.B. Kendr., N.Z. Jl Bot. 6: 351. 1968.

Synnemata straight or flexuous, septate, simple, dark brown, pale brown at apex, 300–980 × 10.5–15 µm. Conidiophores densely grouped, septate, branched at apex, smooth, brown. Conidiogenous cells, monophialidic, terminal, integrated, determinate, pale brown to subhyaline, collarettes inconspicuous. Conidia solitary, 0-septate, lunate, smooth, in slimy mass, hyaline, 12–15.5 × 3.5–5.5 µm. setulae filiform at each end, 1.2–1.8 µm.

Specimen examined: **BRAZIL. Bahia: Senhor do Bonfim,** "Serra da Maravilha", on decaying bark, 11/X/2006, A.C.R. Cruz, HUEFS 129373.

Known distribution: New Zealand (Hughes & Kendrick 1968).

Comments: Only two species of *Dictyochaeta* have synnematal conidiomata. *D. obesispora* has synnemata formed by up to 45 conidiophores and *D. dendroidea* Kuthub. by up to 25 conidiophores. The conidia of *D. dendroidea* are smaller than *D. obesispora* (Kuthubutheen 1987). Conidia and setulae for the examined material are smaller than recorded for the type material (17–21 × 5.4–6.2 µm and 6.4 µm long, respectively). Hughes & Kendrick (1968) referred to the presence of polyblastic conidiogenous cells; however, in the Brazilian material only monoblastic conidiogenous cells were observed. This discrepancy may be related to differences in the age of material. This species is recorded for the first time for the American continent.

Dictyochaeta setosa (S. Hughes & W.B. Kendr.) Whitton, McKenzie & K.D. Hyde, Fungal Diversity 4: 148. 2000. Figs 14–15

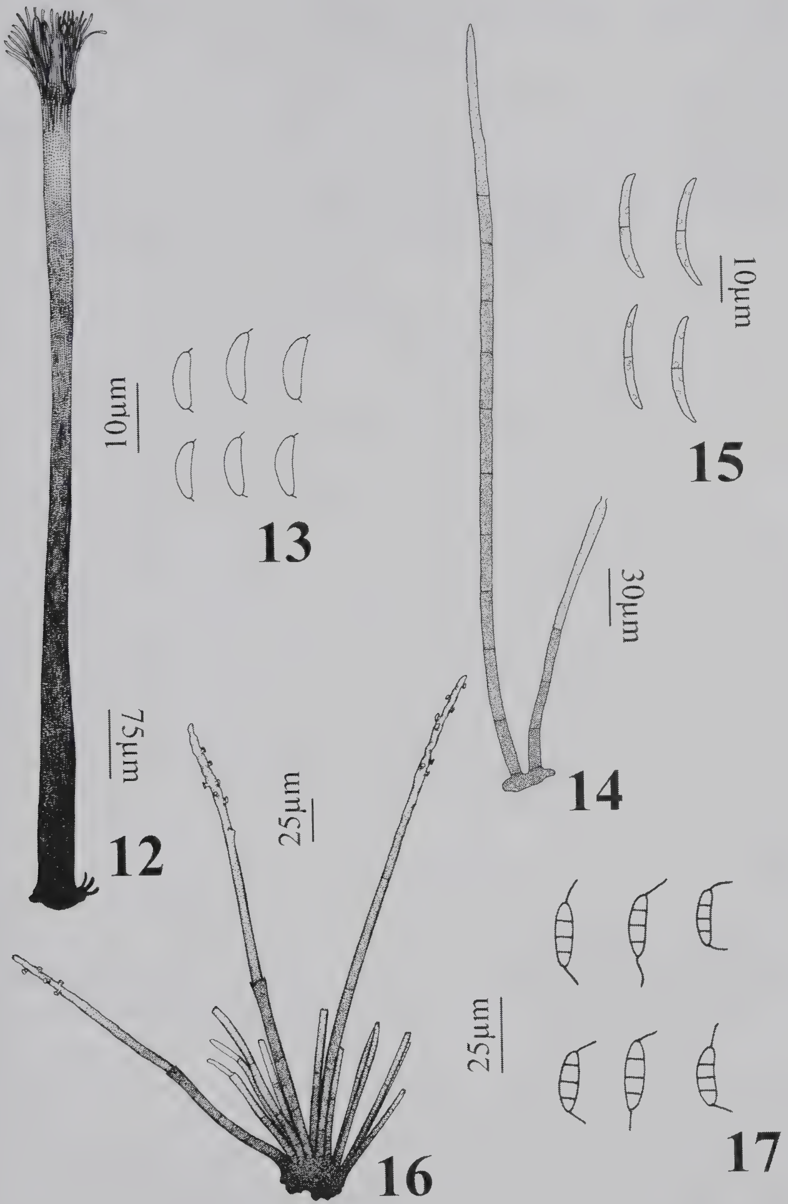
Bas.: *Codinaea setosa* S. Hughes & W.B. Kendr., N.Z.Jl. Bot. 6: 360. 1968.

Setose conidiophores, solitary, erect, straight, septate, smooth, brown at base, pale brown at apex, 246–360 × 4.5–6 µm. Conidiophores macronematous, mononematous, arising solitary or associated with base of setae, straight, septate, simple, smooth, pale brown, 84–189 × 3–4.5 µm. Conidiogenous cells monophialidic, integrated, terminal, determinate, pale brown. Conidia solitary, 1-septate, falcate, simple, smooth, in slimy mass, hyaline, 22.5–31.5 × 1.5–2.2 µm. setulae absent.

Specimen examined: **BRAZIL. Bahia: Santa Terezinha**, Serra da Jibóia, on dead leaves of *Clusia melchiorii*, 26/IV/2006, F.R. Barbosa, HUEFS 1233555.

Known distribution: England (CABI Bioscience Databases), India (Patil et al. 1991), New Zealand (Hughes & Kendrick 1968).

Comments: *Dictyochaeta setosa* is similar to *D. ixorae* (M.S. Patil et al.) Whitton et al., but has larger conidia (Patil et al. 1991). Hughes & Kendrick (1968) described polyblastic conidiogenous cells; however, in examined material only monoblastic cells was observed. The dimensions of setose conidiophores and


12
75µm
10µm
13
14
30µm
15
10µm
16
25µm
17
25µm

Figs 12-13. *Dictyochaeta obesispora*. 12. Synnemata. 13. Conidia.
Figs 14-15. *Dictyochaeta setosa*. 14. Setose conidiophore and conidiophore. 15. Conidia.
Figs 16-17. *Dictyochaeta triseptata*. 16. Conidiophores aggregated with different development stages. 17. Conidia.

conidiophores are bigger than the original description (Hughes & Kendrick 1968). The species is recorded for the first time for the American continent.

Dictyochaeta triseptata (Matsush.) R.F. Castañeda,
Fungi Cubenses I, 8: 1986. FIGS 16–17
Bas.: *Codinaea triseptata* Matsush., Matsush. Mycol. Mem. 2: 4. 1981.

SETAE absent. CONIDIOPHORES macronematous, mononematous, aggregated, rare solitary, with different development stages, straight or flexuous, smooth, dark brown to pale brown at apex, 175–272 × 4.5–9 µm. CONIDIOGENOUS CELLS polyphialidic, integrated, sympodial and percurrent proliferating, pale brown, conspicuous collarettes. CONIDIA solitary, 3-septate, elliptic to lunate, simple, smooth, in slimy mass, hyaline, 18–25.5 × 4.5–7 µm. SETULAE filiform at each end, 6–9 µm.

SPECIMEN EXAMINED: **BRAZIL. BAHIA: Jeremoabo**, "Mata das Pororocas", on dead leaves of unidentified dicotyledon, 18/I/2007, A.C.R. Cruz, HUEFS 129374.

KNOWN DISTRIBUTION: Cuba (Castañeda-Ruiz 1986), Micronesia (Matsushima 1981), Guyana (Cannon & Simmons 2002) and Malaysia (CABI Bioscience Databases).

COMMENTS: *Dictyochaeta triseptata* is morphologically similar to *D. dimorpha* (Toyaz. & Udagawa) Whitton et al., and *D. macrospora*. *D. triseptata* is differentiated from *D. dimorpha*, which has dimorphic conidiophores and conidia, and from *D. macrospora*, which has larger conidia and setulae (Kuthubutheen & Nawawi 1991b). The material examined has smaller conidia than observed by Castañeda-Ruiz (1986); however, it is comparable with observations by Matsushima (1981). Another interesting observation is the conidiophores with different development stages (FIG. 16), information not noted previously for this species.

Other species found in semi-arid regions

Dictyochaeta fertilis (S. Hughes & W.B. Kendr.) Hol.-Jech.,
Folia geobot. phytotax. 19: 426. 1984.

SPECIMENS EXAMINED: **BRAZIL. BAHIA: Senhor do Bonfim**, on decaying fruit, 28/IX/2006, A.C.R. Cruz, HUEFS 129370; **Senhor do Bonfim**, on decaying fruit, 4/X/2006, A.C.R. Cruz, HUEFS 129371.

Dictyochaeta novae-guineensis (Matsush.) A.I. Romero,
Boln Soc. Argent. Bot. 22: 76. 1983.

SPECIMENS EXAMINED: **BRASIL. BAHIA: Campo Formoso**, on decaying bark, 4/X/2006, A.C.R. Cruz, HUEFS 129365; **Senhor do Bonfim**, on dead leaves of unidentified dicotyledon, 5/X/2006, A.C.R. Cruz, HUEFS 129366; **Senhor do Bonfim**, on dead leaves of unidentified dicotyledon, 18/X/2006, A.C.R. Cruz, HUEFS 129367; **PERNAMBUCO: Buíque**, on dead leaves of unidentified dicotyledon, 31/VIII/2006, A.C.R. Cruz, HUEFS 129368; **Buíque**, on dead leaves of unidentified dicotyledon, 8/IX/2006, A.C.R. Cruz, HUEFS 129369.

Dictyochaeta pluriguttulata Kuthub. & Nawawi, Mycol. Res. 95: 1212. 1991.

Specimen examined: **BRAZIL. Pernambuco: Buíque,** on dead leaves of unidentified dicotyledon, 18/VIII/2006, A.C.R. Cruz, HUEFS 129372.

Dictyochaeta simplex (S. Hughes & W.B. Kendr.) Hol.-Jech.,
Folia geobot. phytotax. 19: 434. 1984.

Specimens examined: **BRASIL. Bahia: Paulo Afonso,** on decaying fruit, 28/I/2007, A.C.R. Cruz, HUEFS 129362; **Pernambuco: Buíque,** on dead leaves of unidentified dicotyledon, 28/VIII/2006, A.C.R. Cruz, HUEFS 129363; **Buíque,** on dead leaves of unidentified dicotyledon, 8/IX/2006, A.C.R. Cruz, HUEFS 129364.

Key to *Dictyochaeta* species collected in Brazil

1a. Conidiophores synnematous	*D. obesispora*
1b. Conidiophores mononematous	2
2a. Conidia without setulae	3
2b. Conidia with setulae	5
3a. Conidia non-septate	4
3b. Conidia 1-septate, 22.5–31.5 × 1.5–2.2 µm	*D. setosa*
4a. Conidia cylindrical, 4.2–7.8 × 1–1.2 µm	*D. microcylindrospora*
4b. Conidia ellipsoid to allantoid, 6–9.5 × 1–2.4 µm	*D. heteroderae*
5a. Conidia non-septate	6
5b. Conidia septate	10
6a. Setae or setose conidiophore presents	7
6b. Setae absent	*D. simplex*
7a. Setose conidiophore	*D. fertilis*
7b. Setae	8
8a. Conidia pluriguttulate	9
8b. Conidia non-guttulate, 12.5–19 × 1–2.5 µm	*D. britannica*
9a. Conidia asymmetrical, 20–27 × 2–2.7 µm setulae inconspicuous	*D. pluriguttulata*
9b. Conidia symmetrical, setulae conspicuous, 3.5–6.5 µm long	*D. intermedia*
10a. Conidia 1-septate	11
10b. Conidia 3-septate	12
10c. Conidia 1–3-septate, 17–23 × 2 µm	*D. septata*
11a. Setae present	*D. novae-guineensis*
11b. Setae absent	*D. eucalypti*
12a. Setae present	*D. caatingae*
12b. Setae absent	*D. triseptata*

Acknowledgements

We are deeply indebted to Dr. R.F. Castañeda Ruiz (INIFAT-Cuba) and Dr. Eric McKenzie (Landcare Research, Auckland-New Zealand) for kindly reviewing the manuscript and for many suggestions that greatly improved it. Part of the support for this work came from the Program of Research of Biodiversity in the Brazilian Semi-arid (PPBIO Semi-arid/Ministry of Technology and Science). The authors L.F.P. Gusmão and A.C.R. Cruz thank the CNPq and "Programa de Pós-graduação em Botânica – PPGBot/UEFS". A.C.R. Cruz extends thanks to FAPESB (Proc. APR071/2007).

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Two new species of *Polyschema* and *Vanakripa* and other microfungi recorded from mangrove in Veracruz, Mexico

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Abstract — Two new anamorphic fungi collected on mangrove debris are described and illustrated. *Vanakripa rhizophorae* is characterized by variably shaped, globose, ovoid to ellipsoidal, brown to black, one-celled conidia, and *Polyschema nigroseptatum* is distinguished from related species by clavate to ovoid, 2–3(–5)-septate, brown conidia with black septa. Eleven other species of anamorphic fungi, ten illustrated here, are also recorded from mangrove.

Key words — systematics, tropical rainforest, conidial fungi

Introduction

Mangrove is an important tropical coast biome; it inhabits a productive ecosystem able to export energy and materials to adjacent but poor ecosystems. The mangrove ecosystem that surrounds the La Mancha Lagoon in Veracruz, Mexico, is characterized by a highly complex landscape containing four mangrove species: *Rhizophora mangle* L., *Laguncularia racemosa* (L.)C.F. Gaertn., *Avicennia germinans* (L.)L., and *Conocarpus erectus* L. (Travieso-Bello

& Moreno-Casasola 2006). A distinct group of fungi (manglicolous fungi) occurs in the mangrove habitat, and mangrove fungi have been reported from a range of habitats throughout the tropical world (Kohlmeyer 1969, 1980, 1984; Kohlmeyer & Kohlmeyer 1979, Hyde 1986) and in Malaysia (Jones & Tan 1987). However, most studies on Mexican mangrove biodiversity have dealt with the flora and fauna; anamorphic fungi of the region remain poorly explored.

Materials and methods

The mangrove material studied was collected in La Mancha Coastal Research Center, Veracruz, Mexico (CICOLMA), located 24.5 km north of Cardel City. Material was air dried for 12 h. Damp chambers were prepared in the laboratory and incubated during 7–15 days at 28° C. All the species were studied directly from naturally occurring plant debris. Slides were mounted in polyvinyl alcohol. Specimens cited have been deposited at the herbarium in Xalapa (XAL), Veracruz, México.

Taxonomy

Polyschema nigroseptatum R.M. Arias, R.F. Castañeda & Heredia, **anam. sp. nov.**
MycoBank, MB 511869 **Figs. 3–7**

Coloniae in substrato naturali effusae, nigrae. Mycelium partim superficiale et partim in substrato immersum. Hyphae septatae, ramosae, laeves, brunneae. Conidiophora conspicua, erecta, moniliformia, laevia, 20–38 × 5–7 μm, brunnea. Cellulae conidiogenae monotreticae, globosae vel clavatae, determinatae, 8–10 × 5–7 μm, pallide brunneae, laeves. Conidia solitaria, acrogena, clavata usque ad ovoidea, 2–3(–5)-septata, 41–45 × 19–22 μm, brunnea, atrobrunnea vel nigra ad septa, laevia, sicca.

Holotype: **MEXICO. Veracruz:** La Mancha Coasta Research Center, on bark of *Rhizophora mangle*, 2.VIII.1995, G. Heredia (**HOLOTYPE**: XAL CB896).

Etymology: Latin, *nigroseptatum,* referring to the dark brown to black septa.

Colonies on the natural substrate effuse, black. Mycelium superficial and immersed. Hyphae septate, branched, smooth-walled, brown. Conidiophores conspicuous, erect, moniliform, smooth-walled, 20–38 × 5–7 μm, brown. Conidiogenous cells monotretic, globose or clavate, determinate, 8–10 × 7–10 μm, pale brown, smooth-walled. Conidia solitary, acrogenous, clavate to ovoid, 2–3(–5)-septate, 41–45 × 19–22 μm, brown, but dark brown to black at the septa, smooth-walled, dry.

Notes: Sixteen species are recognized in the genus *Polyschema* H.P. Upadhyay (Castañeda et al 2000): *P. bicellulare* Shearer, *P. chambalense* I.J. Joshi et al.,

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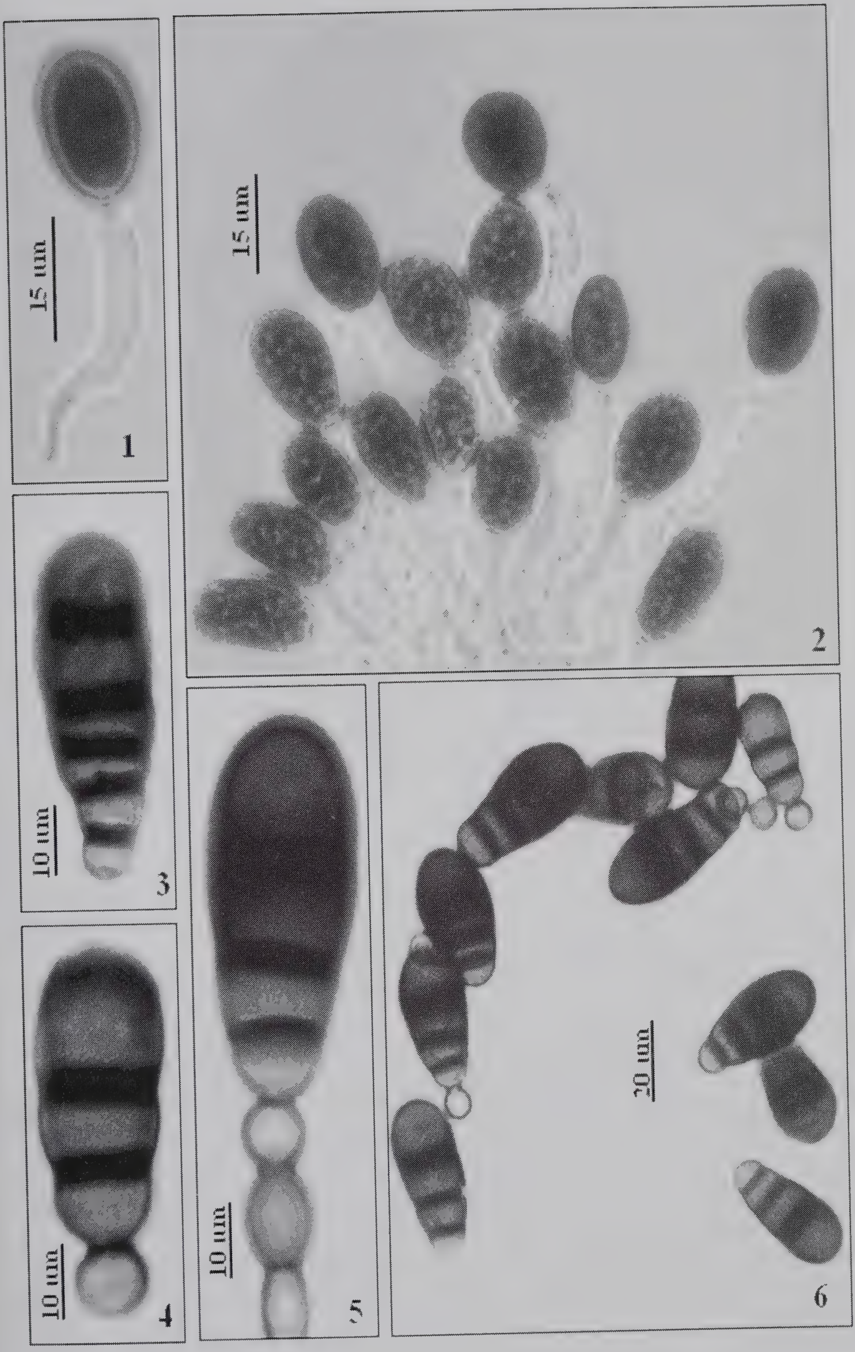
Figs 1-6. 1-2. *Vanakripa rhizophorae* (from XAL CB895). 1. Conidia, separating cells and conidiogenous cells. 2. Sporodochium. 3-6. *Polyschema nigroseptatum* (from XAL CB896). 3-4. Conidiogenous cells and conidia 5-6. Conidiophores, conidiogenous cells and conidia. Scales are indicated by bars.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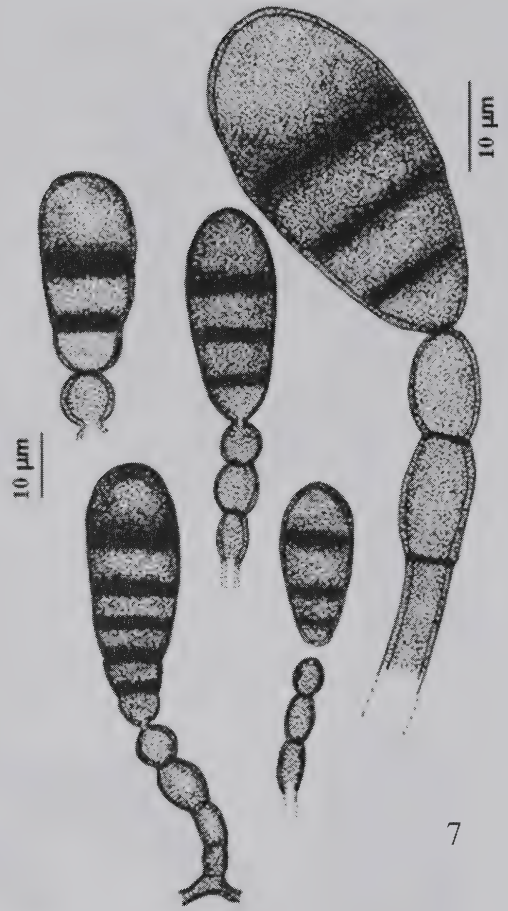


Fig. 7. *Polyschema nigroseptatum* (from XAL CB896).
Conidiophore, conidiogenous cells and conidia. Scales are indicated by bars.

P. clavulatum (Cooke & Harkn.) M.B. Ellis, *P. congolense* Reisinger & Kiffer, *P. cubense* Mercado & J. Mena, *P. indicum* Behera et al., *P. larviforme* (Fairm.) M.B. Ellis, *P. lignicola* V.G. Rao & K.A. Reddy, *P. obclaviforme* R.F. Castañeda & Decock, *P. olivaceum* (Ellis & Everh.) M.B. Ellis, *P. queenslandicum* Matsush., *P. sagari* J.P.N. Pandeya & S.B. Saksena, *P. terricola* H.P. Upadhyay, *P. variabile* D.P. Tiwari et al., *P. venustum* R.F. Castañeda et al., and *P. yakuense* Matsush. (Most authors have treated the genus *Polyschema* — based on the Greek neuter noun, σχημα — as feminine instead of neuter; all the appropriate epithet gender corrections have been incorporated here.) *Polyschema toruloides* Matsush. was not included in Castañeda et al. (2000), since this species was described from

V8JA cultures, and the conidiogenous cells are multilocal, globose to broadly obovate, black or dark brown, verrucose. These characters relate *P. toruloides* more closely to the genus *Dwayabeeja* Subram., but we do not propose a new combination here. *Polyschema indicum* D.P. Tiwari & P.D. Agrawal (published June 1973), which is an illegitimate later homonym of *P. indicum* Behera et al. (published March 1973; see Commonwealth Mycological Institute 1975, Index Fungorum 2008), was also not included in Castañeda et al. (2000). Tiwari & Agrawal (1973) described their species from on potato dextrose agar cultures and the conidia are variably shaped: subglobose, globose, obovate, oval, clavate, obpyriform to pyriform, (1–)2–4-septate (mostly 2-septate), 12.7–29.4 × 8.3–13.3 µm. In fact, the conidia of *P. indicum* D.P. Tiwari & P.D. Agrawal strongly resemble those of *P. indicum* Behera et al. *Polyschema nigroseptatum* is superficially close to *P. variabile* in the shape of the conidia, but the latter has smaller conidia (9.0–28.5 × 6.0–11.5 µm).

Key to *Polyschema* species

1a. Conidia smooth-walled 2
1b. Conidia with ornamented walls 7

2a. Conidia with one septum 3
2b. Conidia with more than one septum 4

3a. Conidia 14–21 × 7–12 µm, obovoid or pyriform, pale to mid brown, with a dark brown band at the septum; apical cell longer than the basal cell . . . . . *P. lignicola*
3b. Conidia 10–12 × 5–6 µm, subclavate to obovoid, reddish brown, without a dark brown band at the septum and with the apical cell three times longer than the basal cell . . . . *P. bicellulare*

4a. Conidia 2–3-septate, oblong, clavate or ellipsoidal, reddish brown, darker at the septa, 11–20 × 5–8 µm . . . . *P. cubense*
4b. Conidia with 3 or more septa 5

5a. Conidia 30–48 × 6–7 µm, obclavate, (4–)5-septate, brown at the middle and pale at the ends . . . . *P. obclaviforme*
5b. Conidia wider than 10 µm, 3–5-septate 6

6a. Conidia 30–46 × 12–16 µm, clavate, 3–5-septate, pale to dark reddish brown, with basal cell paler than the others . . . . *P. clavulatum*
6b. Conidia 41–45 × 19–22 µm, clavate, ovoid, 2–3(–5)-septate, dark brown to black at the septa . . . . *P. nigroseptatum*

7a. Conidia verrucose 8
7b. Conidia tuberculate or papillate 15

8a. Conidia with oblique septa, mostly subglobose, pyriform or clavate, mid to dark brown, 12–35 × 13–18 µm . . . . *P. terricola*
8b. Conidia without oblique septa 9

9a. Conidia usually with a maximum of 7 septa 10
9b. Conidia with more than 7 septa 14

10a. Conidia ellipsoidal to clavate or pyriform 11
10b. Conidia cylindrical, constricted at the septum 13

11a. Conidia 0–5-septate, clavate, gray-brown or dark brown at the upper two cells, pale brown towards the base, 9.0–28.5 × 6.0–11.5 µm .... *P. variabile*
11b. Conidia usually ellipsoid or pyriform 12

12a. Conidia 1–3(mostly 2)-septate, ellipsoidal, sometimes clavate, pale golden brown, 16–26 × 8–11 µm .... *P. congolense*
12b. Conidia 2–4-septate, ellipsoidal or pyriform, mid dark golden brown, paler at the ends, 15–30 × 10–14 µm .... *P. indicum*

13a. Conidia 2–7-septate, constricted at the septa, mid golden brown, 17–37 × 6–9 µm .... *P. olivaceum*
13b. Conidia 1–5-septate, constricted at the septa, pale brown, 5–20 × 3–8 µm .... *P. sagari*

14a. Conidia sometimes catenate, clavate, obclavate, cylindrical to sigmoid, pale brown, 3–9-septate, 13–49 × 6–11 µm .... *P. chambalense*
14b. Conidia not catenate, clavate, obclavate or ellipsoidal, reddish brown to dark reddish brown, 4–12-septate, 30–80 ×12 –20 µm .... *P. larviforme*

15a. Conidia tuberculate, navicular or broadly fusiform, dark brown or black, brown at the ends, 5–10-septate, 30–60 × 13–20 µm .... *P. venustum*
15b. Conidia papillate 16

16a. Conidia ellipsoidal or oblong–ellipsoidal, 2–3-septate, dark brown, paler towards the ends, 13–22 × 6–8 µm .... *P. yakuense*
16b. Conidia clavate to ellipsoid, central cells brown, pale brown at the ends, 2–4(mostly 3)-septate, 20–36 × 9–13 µm .... *P. queenslandicum*

Vanakripa rhizophorae R.M. Arias, Heredia & R.F. Castañeda **anam. sp. nov.**

MycoBank, MB 511867 **Figs. 1–2, 8**

Conidiomata sporodochialia, superficialia, dissita, pulvinata, nigra. Mycelium partim superficiale et partim in substrato immersum, ex hyphis septatis, ramosis, hyalinis, laevibus compositum. Conidiophora inconspicua, mononematosa, hyalina, interdum in cellulis conidiogenis reducta. Cellulae conidiogenae hologenosae, determinatae, cylindricae, hyalinae, in conidiophoris incorporatae. Cellulae separantes clavatae, usque ad vermiformes, 29.4–53.9 × 3.9–9.3, multiguttulatae, laeves, hyalinae. Conidia solitaria, acrogena, variabilia, globosa, ovoidea usque ad ellipsoideae, unicellularia, 16.6–22.3 × 6.3–14.7 µm, atrobrunnea usque ad nigra.

Holotype: **MEXICO. Veracruz,** La Mancha Coasta Research Center, on bark of *Rhizophora mangle*, 2.VIII.1995, G. Heredia (**HOLOTYPE**: XAL CB895).

Etymology: Latin, *rhizophorae,* refers to its growing on *Rhizophora mangle* host.

Colonies on the natural substrate effuse, black. Conidiomata sporodochial, scattered, pulvinate. Mycelium superficial and immersed composed of septate,

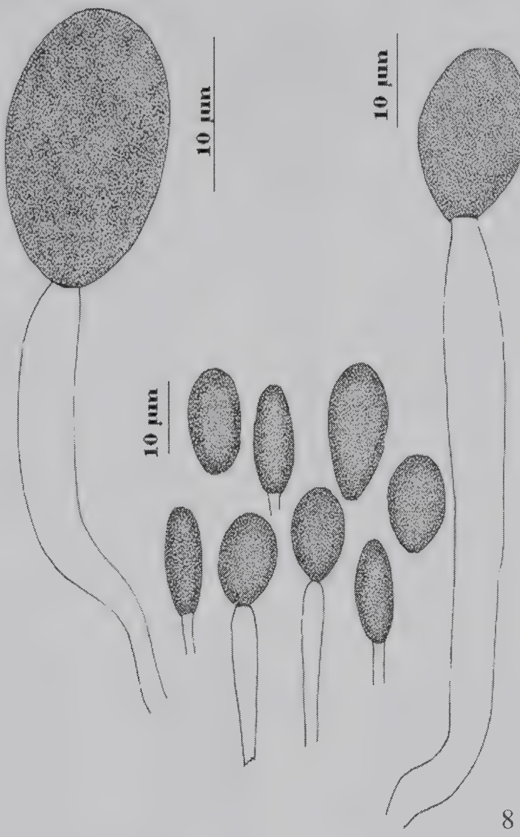


Fig. 8. *Vanakripa rhizophorae* (from XAL CB895).
Conidia and separating cells. Scales are indicated by bars.

branched, hyaline, smooth-walled hyphae. Conidiophores undifferentiated, mononematous, hyaline, sometimes reduced to conidiogenous cells. Conidiogenous cells hologenous, determinate, cylindrical, hyaline, integrated. Separating cells clavate to vermiform, 29.4–53.9 × 3.9–9.3 µm, multi-guttulate, smooth-walled, hyaline. Conidia solitary, acrogenous, variable in shape, globose, ovoid to ellipsoidal, 16.6–22.3 × 6.3–14.7 µm, aseptate, smooth, brown to black.

Notes: The genus *Vanakripa* Bhat et al. currently comprises five species: *V. ellipsoidea* K.M. Tsui et al., *V. fasciata* R.F. Castañeda et al., *V. gigaspora* Bhat et al., *V. minutiellipsoidea* Pinnoi and *V. parva* Bhat et al. *Vanakripa rhizophorae* produces black conidia with hyaline, clavate separating cells, but the conidia are variable in shape, ranging from globose, ovoid to ellipsoidal; it is close to *V. parva* but differs in having larger conidia.

Key to *Vanakripa* species

1a. Conidia one-celled 2
1b. Conidia with a submedian septum, clavate to obpyriform, smooth-walled, dark brown to black, basal cell pale brown, 33–40 × 19–23 µm .... *V. gigaspora*

2a. Conidia small, 7–10 × 4–6 µm, ovoid, with rounded apex, brown to dark brown, smooth-walled .... *V. parva*
2b. Conidia much larger, more than 20 × 14 µm 3

3a. Conidial shape variable, globose, ovoid to ellipsoidal, 16.6–22.3 × 6.3–14.7 µm, smooth-walled, dark brown to black .... *V. rhizophorae*
3b. Conidial shape uniform 4

4a. Separating cells relatively narrow, 17–30 × 6–9 µm, clavate, hyaline; conidia ellipsoidal, with rounded apex, brown to dark brown with a central zone or a black transverse band, smooth-walled, 24–34 × 16–23 µm .... *V. fasciata*
4b. Separating cells much wider, more than 10 µm 5

5a. Conidia 25–33 × 16–23 µm, ellipsoidal, with rounded apex and base, dark brown to black, smooth-walled; separating cells clavate to vermiform, 30–70 × 10–22.5 µm, hyaline .... *V. minutiellipsoidea*
5b. Conidia longer; 33–42 × 20–25 µm, ellipsoid, with rounded apex, dark brown to black, smooth-walled, separating cell clavate to vermiform, 30–72 × 11–16 µm, smooth-walled, hyaline .... *V. ellipsoidea*

Other anamorphic fungi recorded from mangrove

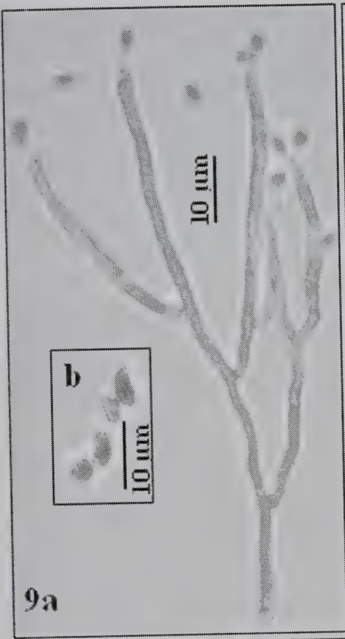
Coniosporium memorandum (Penz. & Sacc.) M.B. Ellis, Mycol. Pap. 125: 2 (1971). (Fig. 16)

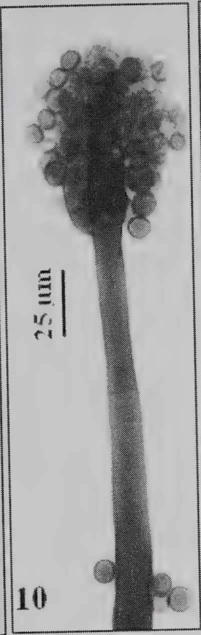
Specimen examined: MEXICO. Veracruz, La Mancha Coasta Research Center, on dead leaves of *Avicennia germinans*, 2.VIII.1995, G. Heredia (CB 884, CB884-1).

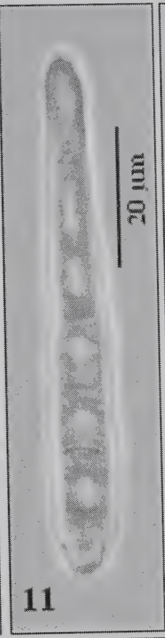
Corynespora kamatii (V.G. Rao) M.B. Ellis, More Dematiaceous Hyphomycetes (Kew): 376 (1976). (Fig. 11)

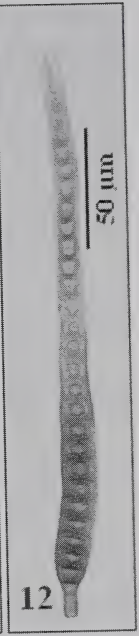
Specimen examined: MEXICO. Veracruz, La Mancha Coasta Research Center, on dead stems of *Rhizophora mangle*, 11.VIII.1995, G. Heredia (CB885, CB885-1).

Figs 9-18. 9 a-b. *Virgaria nigra*, a - Conidiophores b - Conidia. 10. *Periconia minutissima*, conidiophores, condiogenous cells and conidia. 11. *Corynespora kamatii*, conidium. 12. *Ellisembia adscendens*, conidium. 13. *Helicoma proliferens*, conidiogenous cell and conidium. 14. *Intercalarispora nigra*, conidium. 15. *Mycoenterolobium platysporum*, conidium. 16. *Coniosporium memorandum*, conidia. 17. *Pseudopetrakia kambakkamensis*, conidium. 18. *Tetracoccosporium aerium*, conidia. Scales are indicated by bars.


9a
b
10 µm
10 µm


10
25 µm


11
20 µm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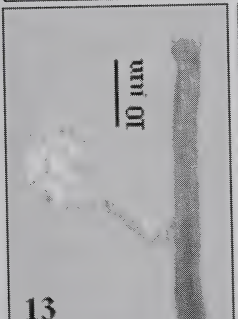
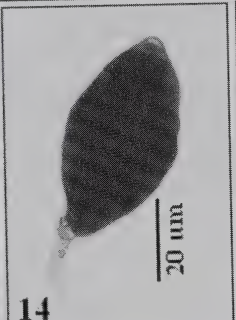
50 µm


13
10 µm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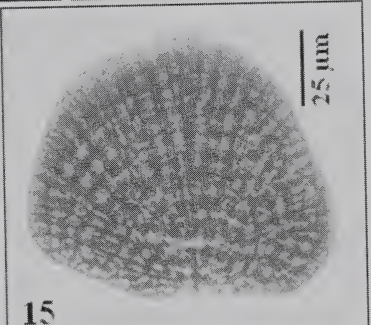
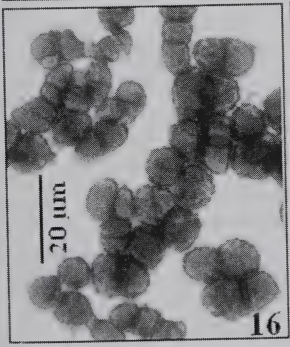
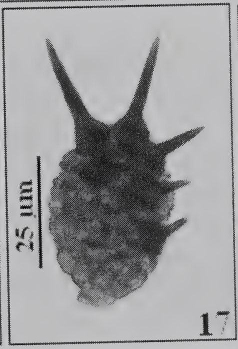
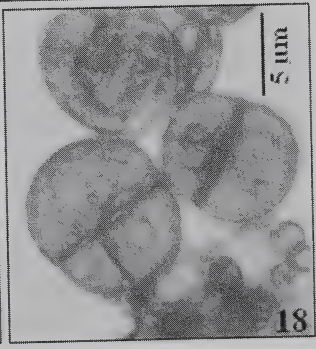
20 µm


15
25 µm


16
20 µm


17
25 µm


18
5 µm

Ellisembia adscendens (Berk.) Subram., Proc. Indian Natl. Sci. Acad., B, Biol. Sci. 58(4): 183 (1992). (Fig. 12)

Specimen examined: MEXICO. **Veracruz,** La Mancha Coasta Research Center, on dead stems of *Avicennia germinans*, 1.VIII.1995, G. Heredia (CB886, CB886-1, CB886-2).

Helicoma proliferens Linder, Ann. Missouri Bot. Gard. 16: 309 (1929). (Fig. 13)

Specimen examined: MEXICO. **Veracruz**, La Mancha Coasta Research Center, on bark of *Rhizophora mangle*, 1.VIII.1995, G. Heredia (CB887).

Intercalarispora nigra J.L. Crane & Schokn., in Schoknecht & Crane, Canad. J. Bot. 61(8): 2243 (1983). (Fig. 14)

Specimen examined: MEXICO. **Veracruz**, La Mancha Coasta Research Center, on bark of *Rhizophora mangle*, 2.VIII.1995, G. Heredia (CB894).

Mycoenterolobium platysporum Goos, Mycologia 62(1): 172 (1970). (Fig. 15)

Specimen examined: MEXICO. **Veracruz**, La Mancha Coasta Research Center, on stalk of *Rhizophora mangle*, 17.VIII.1995, G. Heredia (CB888, CB888-1).

Periconia minutissima Corda, Icon. fung. (Prague) 1: 19 (1837). (Fig. 10)

Specimen examined: MEXICO. **Veracruz**, La Mancha Coasta Research Center, on stalk of *Rhizophora mangle*, 2.VIII.1995, G. Heredia (C 889).

Pseudopetrakia kambakkamensis (Subram.) M.B. Ellis, Mycol. Pap. 125: 4 (1971). (Fig. 17)

Specimen examined: MEXICO. **Veracruz**, La Mancha Coasta Research Center, on bark of *Rhizophora mangle*, 1.VIII.1995, G. Heredia (CB890).

Tetracoccosporium aerium P.C. Misra & P. Srivast., Mycotaxon 4(1): 276 (1976). (Fig.18)

Specimen examined: MEXICO. **Veracruz**, La Mancha Coasta Research Center, on bark of *Avicennia germinans*, 23.VIII.1995, G. Heredia (CB891, CB891-1).

Verticillium chlamydosporium var. ***catenulatum*** (Kamyschko ex Onions & G.L. Barron) W. Gams, Netherlands. J. Pl. Pathol. 94(3): 134 (1988).

Specimen examined: MEXICO. **Veracruz**, La Mancha Coasta Research Center, on bark of *Rhizophora mangle*, 2.VIII.1995, G. Heredia (CB892, CB892-1).

Virgaria nigra (Link) Nees, Syst. Pilze: 54 (1817). (Fig.9)

Specimen examined: MEXICO. **Veracruz**, La Mancha Coasta Research Center, on bark of *Avicennia germinans*, 1.VIII.1995, G. Heredia (CB893).

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New cercosporoid fungi from the Brazilian Cerrado 1. Species on hosts of the families *Anacardiaceae*, *Araliaceae*, *Bombacaceae*, *Burseraceae* and *Celastraceae*

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Abstract — New cercosporoid hyphomycetes are described from the Brazilian Cerrado on native plants of the families *Anacardiaceae* (*Pseudocercospora astronii*, *P. astroniiphila*), *Araliaceae* (*Passalora schefflerae*), *Bombacaceae* (*Cercospora ochromae*, *Pseudocercospora eriothecae*, *P. pseudobombacis*), *Burseraceae* (*Pseudocercospora protii*), and *Celastraceae* (*Prathigada austroplenckiae*, *Pseudocercospora austroplenckiae*).

Key words — fungal taxonomy, mycodiversity, *Mycosphaerellaceae*, tropical hyphomycetes

Introduction

The Cerrado is the second largest Brazilian biome, surpassed only by the Amazonian Forest. The floristic richness of the Cerrado includes a total of 6671 native taxa, distributed in 170 families and 1144 genera. There are 6429 species and 451 varieties and subspecies, respectively, including 264 species belonging to the pteridophytes (in 19 families and 51 genera), two to the gymnosperms (*Podocarpus*, *Podocarpaceae*) and 6060 to the angiosperms (in 150 families and 1092 genera) [according to Mendonça et al. (1998)].

Although the majority of Cerrado plants are well documented, little is known about their associated microfungi. The exploration of Cerrado microfungi dates back to the end of the 19th century with first contributions by some American and European mycologists, including P. Hennings, E.W.D. Holway and H.S. Jackson. However, the most important contributions were made by the Brazilian mycologists A.P. Viégas and A.C. Batista, who described more than 240 species from the Cerrado (Dianese et al. 1997). The most comprehensive contribution to the knowledge of the cercosporoid fungi of Brazil was undoubtedly published by Viégas (1945), which was later used by Chupp (1954) for the preparation of his monograph of *Cercospora* Fresen. Since then, only fragmentary treatments of Brazilian cercosporoid fungi were published (Dianese & Câmara 1994, Medeiros 1994, Barreto & Evans 1995, Crous & Braun 1996, Inácio et al. 1996, Crous et al. 1997, Inácio & Dianese 1999, Furlanetto & Dianese 1999, Braun et al. 1999, Braun & Freire 2002, 2004, 2006). In this paper cercosporoid hyphomycetes found on native Cerrado plants belonging to five host families are described following the generic concepts introduced by Deighton (1967, 1974, 1976) and updated by Braun (1999) as well as Crous & Braun (2003). The collections studied are deposited in the Mycological Collection of the Herbarium of the University of Brasilia (Herbarium UB - mycological collection).

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[1]Portion of the Doctor´s Thesis of the senior author

Materials and methods

Starting in 1992, Cerrado fungi were extensively collected from different regions representative for this biome (Dianese et al. 1997). The plant samples containing the fungi were pressed and dried in a drying-chamber during 3–4 days at ca. 50°C, then they were exsiccated, labeled and frozen for 7–8 days at temperatures between −30°C and −50°C, and finally they were re-dried in an oven during 24 h at temperatures between 50–70°C before being deposited in the Mycological Collection of the Herbarium UB. For the study of cercosporoid fungi associated with different hosts, observations under a stereomicroscope were made to describe the lesions as well as the location and characteristics of the fungal colonies. For the morphological studies, each specimen was mounted on slides using the following media: lacto-glycerol/cotton blue, glycerol-KOH/basic floxine and polyvinyl alcohol (PVA 4.165 g, acetic acid 25 ml, glycerol 2.5 ml, distilled water 25 ml; this preparation was autoclaved for 15 min. and left to rest for 24 h before use) (Omar et al. 1979). Mounting media without stains were also used to determine the exact color of different structures, and cotton blue and basic floxine solutions were used to observe the conidial septation and conidiogenous cells. To verify the relationship between the fungus and the host, pieces of the dried vegetal material containing the lesions were re-hydrated for 4–12 h using an aqueous solution containing 10% ethanol and 0,1% Tween–20. Then 7–10 µm thick sections were produced using a freezing microtome (MICRON, HM505E, Micron Laborgeräte, Walldorf, Germany).

Fungal material was studied using a compound light microscope (Zeiss Ultraphot III, Carl Zeiss, Oberkochen, Germany) provided with a camera lucida for drawings. A calibrated ocular micrometer was used to measure (length and width, or diameter) fungal structures (stromata, conidiophores, conidiogenous cells and conidia). Whenever possible between 40 and 50 measurements were done. Numerical data such as number of conidiophores per fascicles, septa and conidiogenous loci, were observed.

A detailed drawing of each specimen was produced showing the location of lesions, extension and shape of the symptoms on the host, and colony features, together with a camera lucida scaled drawing of a micrometric section of the infected plant tissue containing details of stromata, conidiogenous cells and conidia. The drawings were prepared using A4 white layout paper using Pilot (Japan) pens, with points of 0.1, 0.2, 0.3, and 0.5 mm diam.

Taxonomy

Cercosporoid fungi on *Anacardiaceae*

The family *Anacardiaceae* comprises 76 genera and 600 species, tropically and sub-tropically distributed, except for the genus *Rhus* occurring in temperate regions. This family is represented in the Cerrado with eight genera (*Anacardium, Astronium, Lithrea, Myracrodruon, Schinopsis, Schinus, Spondias* and *Tapirira*) and 20 species, among them five species belonging in *Astronium* (Mendonça et al. 1998). Numerous cercosporoid species have been described from hosts of the *Anacardiaceae* (Viégas 1945, 1961; Chupp 1954, Braun 1995, 1998; Hsieh & Goh 1995). On *Astronium* spp. two cercosporoids are known: *Passalora myracrodruonis* (Inácio & Dianese) U. Braun & Crous (≡ *Mycovellosiella myracrodruonis* Inácio & Dianese), described on *Myracrodruon urundeuva* M. Allemão (≡ *Astronium urundeuva* (M. Allemão) Engl.) from the Brazilian Cerrado (Inácio & Dianese 1999), and *Pseudocercospora astroniicola* U. Braun & F. O. Freire (Braun & Freire 2002), introduduced for a cercosporoid fungus on *Astronium fraxinifolium* Schott in the Brazilian State of Ceará. Two species belonging in other fungal groups are also known on *A. fraxinifolium*, an important *Anacardiaceae* from the Cerrado, viz. *Phyllachora astronii* Speg. (Medeiros 1994) and the rust fungus *Kimuromyces cerradensis* Dianese et al. (Dianese et al. 1995).

Two new *Pseudocercospora* Speg. species on *A. fraxinifolium* and *A. urundeuva* have recently been found in the Cerrado.

Pseudocercospora astronii A. Hern.-Gut. & Dianese **sp. nov.** FIG. 1

MYCOBANK, MB 512026

Pseudocercosporae astroniicolae similis, sed hyphis superficialibus et conidiophoris solitariis nullis, cellulis conidiogenis geniculatis, locis conidiogenis subconspicuis, leniter prominentibus, planatis, leviter incrassatis, conidiis longioribus, 20–76 µm, deinde 4–7-septatis, septo basali constricto et incrassato.

SPECIMENS EXAMINED: **BRAZIL. MINAS GERAIS**: DIVINÓPOLIS, Feira Agropecuária, on living leaves of *Astronium fraxinifolium* (*Anacardiaceae*), 12 Jun 1995, *leg. C. A. Inácio* 132, **holotype** (UB Col. Micol. 8992). MINAS GERAIS: DIVINÓPOLIS, Feira Agropecuária, on living leaves of *Astronium urundeuva* (*Anacardiaceae*), 26 Jun 1995, *leg. C. A. Inácio* 318, **paratype** (UB Col. Micol. 17811).

LESIONS 1–14 mm diam., irregular, amphigenous, dark brown, coalescent, without a definite margin. COLONIES mainly hypophyllous. STROMATA brown to dark brown, subepidermal, textura globosa, 28–65 µm diam. CONIDIOPHORES fasciculate, straight to slightly curved, lageniform, short, 17–24 µm long, 3–4 µm

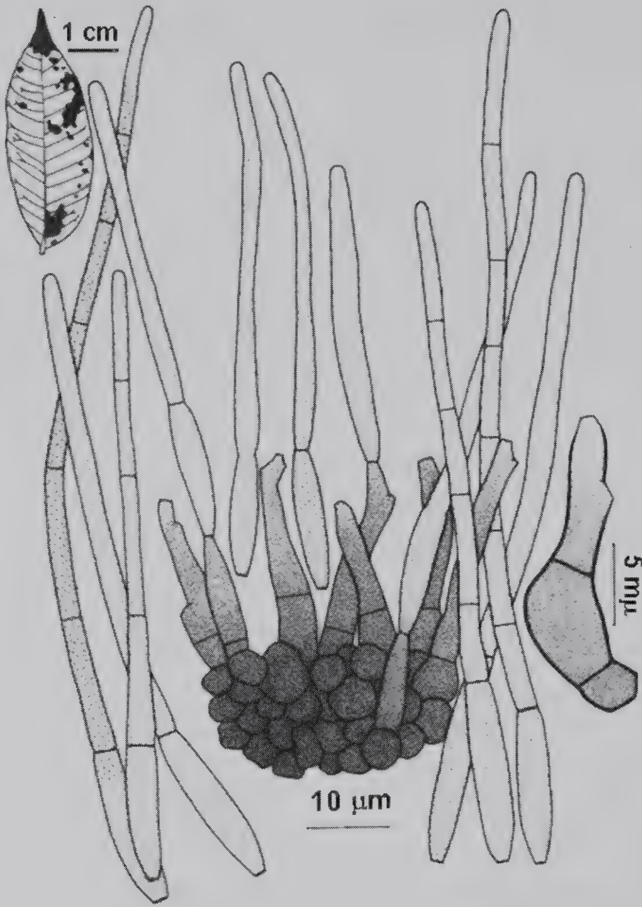

Fig. 1. *Pseudocercospora astronii* on *Astronium fraxinifolium*. Distribution of lesions on a leaf (top left); stroma and conidiophores with conidiogenous cells bearing inconspicuous conidiogenous loci sided by obclavate conidia; a detailed view of the conidiogenous cell (right). Based on the holotype (UB Mycol. Col. 8992).

diam. in the widest part, light brown to olivaceous, paler toward the apex, 0–1-septate, smooth, apex truncate, 1–3 geniculate, thin-walled. Conidiogenous cells integrated, terminal, polyblastic, sympodial, geniculate; conidiogenous loci slightly prominent, smooth, barely thickened, but not pigmented. Conidia solitary, straight, curved or flexuous, subcylindrical to narrowly obclavate, aseptate when young, 4–7-septate when mature, basal septum constricted and thicker than the others, 20–76 µm long, 2–4 µm diam. at the widest part, 1–2 µm diam. at the base and 1–3 µm diam. close to the apex, mostly smooth, sometimes finely verruculose.

Pseudocercospora astroniiphila A. Hern.-Gut. & Dianese **sp. nov.** FIG. 2

MycoBank, MB 512035

Pseudocercosporae astronii similis, sed conidiophoris saepe cylindraceis, 1–3-septatis et non geniculatis, conidiis saepe rectis, levibus et uniformiter distincte septatis, sine constrictione. Differt a P. astroniicola hyphis superficialibus et conidiophoris solitariis nullis.

Specimens examined: **BRAZIL. Minas Gerais**: Divinópolis, Feira Agropecuária, on living leaves of *Astronium urundeuva* (*Anacardiaceae*), 26 Jun 1995, *leg. C. A. Inácio* 320, **holotype** (UB Col. Micol. 8999). **Minas Gerais**: Divinópolis, Feira Agropecuária, on living leaves of *Astronium urundeuva* (*Anacardiaceae*), 1 Jul 1995, *leg. C. A. Inácio* 314, **paratype** (UB Col. Micol. 8992).

Lesions 2–5 mm diam., irregular, brown. Mycelium immersed in the substratum. Colonies hypophyllous. Stromata 18–60 µm diam., well-developed, textura globosa, subcuticular or subepidermal, erumpent, olivaceous. Conidiophores compactly fasciculate, straight, flexuous or curved, cylindrical to slightly lageniform, 2–3-septate, 15–21 µm long, 3–4 µm diam. at the widest part, olivaceous, thin-walled, smooth. Conidiogenous cells integrate, terminal, mostly monoblastic, occasionally sympodial; conidiogenous loci inconspicuous, flattened, non-pigmented. Conidia solitary, straight, curved or flexuous, cylindrical to slightly obclavate, 0–6-septate, 28–72 µm long, 2–4 µm diam. at the widest part, 1–2 µm diam. at the base and at the apex, rounded at the apex; conidial base truncate to obconical truncate, light olivaceous to subhyaline, smooth, unthickened.

Comments: *Pseudocercospora astroniicola* (Braun & Freire 2002), described from the Brazilian State of Ceará on *A. fraxinifolium*, is the only comparable species on a host belonging to the genus *Astronium* including the closely allied genus *Myracrodruon*. The two new species (*P. astronii* and *P. astroniiphila*) are distinguished from *P. astroniicola* by having uniformly fasciculate conidiophores, i.e. superficial hyphae with solitary conidiophores are lacking. In addition, *P. astronii* differs from *P. astroniicola* in having conidiogenous cells with subconspicuous, slightly prominent, truncate conidiogenous loci and longer conidia, 4–7-septate when mature, constricted at the basal septum, which is thicker than the other septa. *Pseudocercospora astronii* was found on *A. fraxinifolium* as well as *M. urundeuva*, on the latter host sometimes together with *P. astroniiphila* on the same lesion, but *P. astroniiphila* was confined to leaves of *A. urundeuva*. *Pseudocercospora astronii* differs from *P. astroniiphila* in having strictly lageniform, geniculate, 1-septate conidiophores and straight or sometimes slightly curved and slightly verruculose conidia, with

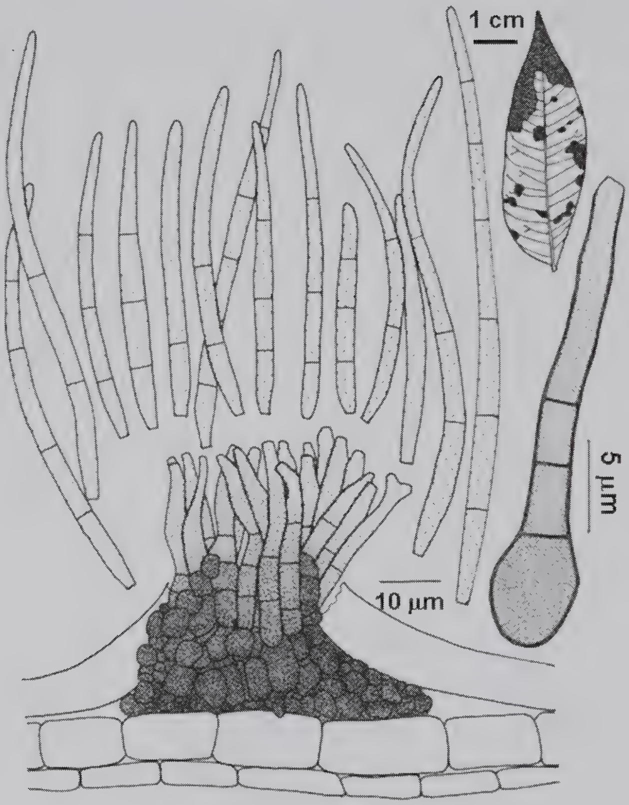

Fig. 2. *Pseudocercospora astroniphila* on *Astronium urundeuva*. Lesions on a leaf (top right); erumpent-subcuticular stroma with a fascicle of conidiophores bearing conidiogenous cells; a representative sample of conidia; a detailed view of a conidiophore (bottom right). Based on the holotype (UB Mycol. Col. 8999).

a constriction at the thicker basal septum (versus conidiophores cylindrical, 2–3-septate, seldom geniculate and conidia generally straight, smooth-walled, with conidial septa conspicuous and without constrictions in *P. astroniiphila*). *Pseudocercospora comocladiae* (Petr. & Cif.) Deighton and *P. mombin* (Petr. & Cif.) Deighton are two morphologically similar species described on hosts belonging to other genera of the *Anacardiaceae* (Chupp 1954, Deighton 1976).. *P. comocladiae* is distinct from *P. astronii* and *P. astroniiphila* by its very short, aseptate conidiophores, 5–15 µm long. The conidia are uniformly septate, without any constrictions. *P. mombin* differs from *P. astronii* in having aseptate conidiophores and uniformly septate conidia without any constrictions, and from *P. astroniphiila* in shorter, aseptate conidiophores. *P. rhinocarpi* U. Braun

& Crous (Crous & Braun 2003) on *Anacardium* in Venezuela has much smaller stromata, only 10–30 µm diam., and shorter, 1-4-septate conidia, 10–50 × 1.5–3.5 µm in comparison to both new species.

Cercosporoid fungi on *Araliaceae*

Seventy genera belong to the family *Araliaceae*, distributed mainly in three tropical zones: the Indo-Malayan region, Australia and Neotropica. Six genera are known from the Cerrado: *Dendropanax*, *Didymopanax*, *Oreopanax*, *Pentapanax*, *Sciadodendron* and *Schefflera*, comprising sixteen species (Mendonça et al. 1998). Cercosporoid hyphomycetes in the genera *Cercospora*, *Cercosporella* Sacc., *Pseudocercospora*, and *Pseudocercosporella* Deighton have been described from several hosts of the *Araliaceae* (Chupp 1954, Viégas 1961, Farr et al. 1989, Hsieh & Goh 1990, Guo & Hsieh 1995, Braun 1995, 1998, Crous & Braun 2003). However, the new species found in the Cerrado on *Schefflera macrocarpa* (Cham. & Schltdl.) Frodin represents the first *Passalora* Fr. species on an *Araliaceae*. There is no comparable species.

Passalora scheffleræ A. Hern.-Gut. & Dianese, **sp. nov.** FIG. 3
MYCOBANK, MB 512037

Laesiones minutae, punctiformes vel 7–8 mm diam., amphigenae, angulares vel irregulares, pallido- vel atro-brunneae. Coloniae abaxiales, punctiformes, 7–8 µm diam., velutinae, inter trichomata. Mycelium immersum. Stromata 25–96 µm diam., primo substomatalia, deinde suprastomatalia, e textura globosa composita, bene evoluta, atro-brunnea. Conidiophora in fasciculis laxe aggregatis, ramosa, inter trichomata. Cellulae conidiogenae in conidiophoris incorporatae, terminales vel intercalares, polyblasticae, cicatricibus conspicuis, incrassatis et fuscatis, 2–4 µm latis. Conidia solitaria, recta, curvata vel flexuosa, cylindrica, leviter clavata vel obclavata, ad basem obconica vel obconico-truncata, pallido-brunnea vel olivacea, laevia, 21–96 µm longa, 5–10 µm lata in parte latissima, 2–6 µm lata ad basem, 3–10 µm lata prope apicem, 0–7-septata, septo in medio crassiori et atriori; hilum incrassatum et fuscatum.

SPECIMENS EXAMINED: **BRAZIL. GOIÁS**: CRISTALINA, FAZENDA NOVA ÍNDIA, on living leaves of *Schefflera macrocarpa* (*Araliaceae*), 19 Apr 1993, *leg. J.C. Dianese* 1058, **holotype** (UB mycol. col. 4464). **DISTRITO FEDERAL**: BRASÍLIA, Parque Nacional de Brasília, on living leaves of *S. macrocarpa* (*Araliaceae*), 22 Jan 1998, *leg. E.A. Teixeir* 6, **paratype** (UB mycol. col. 15831). **GOIÁS**: CRISTALINA, Fazenda Nova Índia, on living leaves of *Schefflera macrocarpa* (*Araliaceae*), 13 Oct 1993, *leg. J.C. Dianese* 1316, **paratype** (UB mycol. col. 5155).

LESIONS small, punctiform or up to 7–8 mm diam., amphigenous, angular or irregular, light to dark brown. COLONIES abaxial, velvety. MYCELIUM immersed. STROMATA at first substomatal, later suprastomatal-erumpent, dark brown, well-developed, *textura globosa*, 25–96 µm diam. CONIDIOPHORES in loose fascicles, branched, intermixed with the trichomes. CONIDIOGENOUS CELLS integrated, terminal or intercalary, polyblastic; conidiogenous loci protuberant, thickened, darkened, 2–4 µm diam. CONIDIA solitary, 21–96 µm long, 5–10 µm diam.

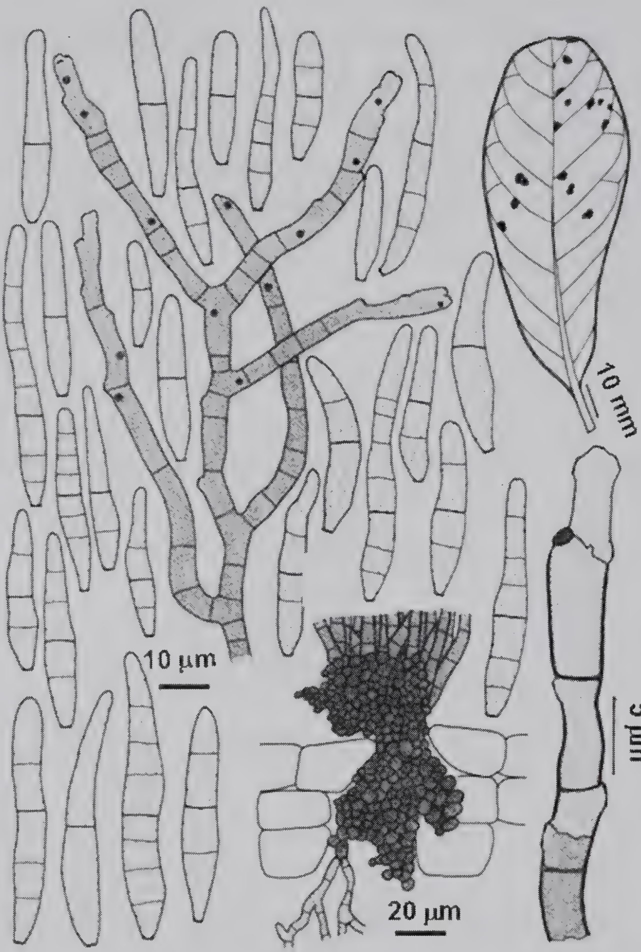

Fig. 3. *Passalora schefflerae* on *Schefflera macrocarpa*. Lesions on a leaf (top right); a representative sample of conidia; branched superficial secondary mycelium; substomatal erumpent stroma bearing a fascicle of conidiophores. Based on the holotype (UB Mycol. Col. 4464).

at the widest part, 2–6 µm at the base and 3–10 µm near the apex, simple, straight, curved or flexuous, light-olivaceous to olivaceous, smooth, cylindrical to slightly clavate or obclavate, obconically truncate at the base, 0–7-septate, with a thicker, darker septum in the middle; hilum thickened and darkened.

COMMENTS: Due to the basic features of this cercosporoid fungus on *Schefflera*, i.e. conspicuously thickened and darkened conidiogenous loci and conidial hila as well as pigmented conidia, it can be assigned to *Passalora* as emended by Crous & Braun (2003). Nevertheless, this species is very unusual by having very large stromata with densely fasciculate, frequently branched conidiophores which are intermingled among trichomes. However, characteristics of the stromata within the *Cercospora* complex are considered "...useful for species delimitation, but inappropriate for generic discrimination..." (Braun 1995). Branched appendages are unusual in *Passalora,* but they may occur in a few species, e.g. *P. bacilligera* (Mont. & Fr.) Mont. & Fr. (Ellis 1971). However, the intensity and frequency of branching in *P. schefflerae* is stronger than in all comparable species.

Cercosporoid fungi on *Bombacaceae*

Bombacaceae is a pantropical family with 28 genera, distributed mainly in Neotropica. In the Cerrado, this biome encompasses seven genera (*Bombax, Cavanillesia, Ceiba, Chorisia, Eriotheca, Pseudobombax* and *Quararibea*) and 17 species, among them five belonging in *Eriotheca* (Mendonça et al. 1998). *Ochroma* comprises bombacaceous species typical of the Amazonian basin or transitional forests. However, the material examined here was obtained from a plant grown as ornamental on the Campus of the Universidade de Brasilia. Several cercosporoid hyphomycetes are known from hosts of the *Bombacaceae,* e.g. *Cercospora bombacicola* Munjal et al., *C. bombacis* Goh & W.H. Hsieh, *C. ceibae* Chupp & Viégas, *Pseudocercospora bombacina* (T.S. Ramakr. & K. Ramakr.) Deighton, *P. eriodendri* (Racib.) U. Braun (= *Cercospora italica* Curzi), *P. pachirae* U. Braun et al. (≡ *C. pachirae* Chupp & A.S. Mull., nom. inval.), *Ramularia chorisiae* Viégas (Chupp 1954, Vasudeva 1963, Braun 1998, Hsieh & Goh 1990, Crous & Braun 2003). Silva & Minter (1995) listed 26 fungal species on hosts of the family *Bombacaceae* studied by Batista and co-workers, among them just 17 are hyphomycetes but none belonging in the *Cercospora* complex. Three new cercoporoid species found on bombacaceous hosts have recently been found in the Cerrado and are now described.

Cercospora ochromae A. Hern.-Gut. & Dianese, **sp. nov.** FIG. 4

MYCOBANK, MB 512038

Cercosporae ceibae similis, sed conidiis cylindraceis-obclavatis, basi obconice truncata.

SPECIMEN EXAMINED: **BRAZIL. DISTRITO FEDERAL:** BRASÍLIA, Campus of Universidade de Brasília, on living leaves of *Ochroma* sp. (*Bombacaceae*), 31 Jul 1994, *leg. JC Dianese* 1766, **holotype** (UB mycol. col. 6317).

LESIONS 1–8 mm diam., amphigenous, small, punctiform, irregular, light brown to brown, surrounded by a yellow halo. COLONIES grayish, shiny, mainly hypophyllous. STROMATA poorly developed, superficial, *textura globosa*, 11–52 µm diam. CONIDIOPHORES densely fasciculate, straight, flexuous, 33–63

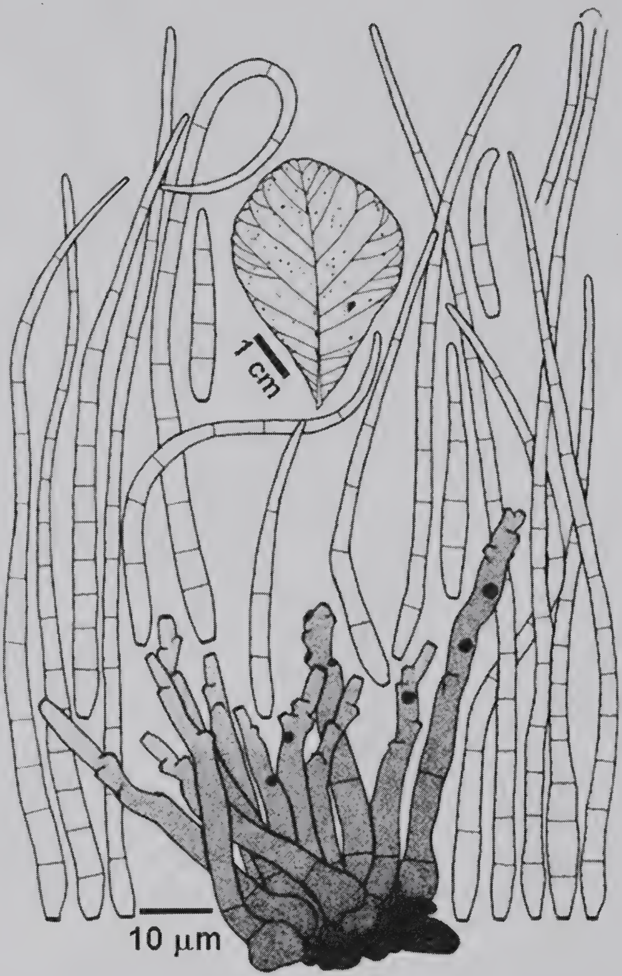

Fig. 4. *Cercospora ochromae* on *Ochroma* sp. Lesions on a leaf (top center) among conidia, around a dark stroma bearing typical *Cercospora* geniculate conidiophores with conidiogenous cells showing darkened conidiogenous loci. Based on the holotype (UB Mycol. Col. 6317).

µm long, 4–6 µm diam. at the widest portion, 0–2-septate, light brown, but subhyaline at the apex, thin-walled, smooth. Conidiogenous cells 40–55 µm long, 2–3 µm diam., integrated, polyblastic, sympodial, with 2–7 geniculations, with thickened, darkened, prominent conidiogenous loci. Conidia solitary, straight, flexuous, sometimes curved, cylindrical to obclavate, obconically truncate at the base with a thickened and darkened hilum, apex acute or round, 25–147 μm long, 2–4 μm diam. at the widest part, 2–3 μm at the base and 1–2 μm near apex, 2–16-septate, subhyaline, smooth, thin-walled.

COMMENTS: Due to pigmented conidiophores, thickened and darkened conidiogenous loci and solitary, hyaline conidia, *Cercospora ochromae* is a typical *Cercospora*. It is close to *C. ceibae*, which is also characterized by having rather short conidiophores with few septa, but the latter species differs from *C. ochromae* in having acicular conidia with truncate base. On account of the acicular conidia, Crous & Braun (2003) classified this species as part of the *Cercospora apii* Fresen. complex. *Cercospora bombacicola* and *C. bombacis* are two species with much longer, pluriseptate conidiophores and acicular conidia with truncate base, reduced to synonymy with *C. apii* s. lat. by Crous & Braun (2003).

Pseudocercospora pseudobombacis A. Hern.-Gut. & Dianese, **sp. nov.** FIG. 5
MYCOBANK, MB 512039

Differt a Pseudocercospora bombacina, P. eriodendri et P. pachirae conidiis longioribus et imprimis distincte latioribus, 27–95 × 5–9 μm, crassitunicatis, 1–14 transverse et 1–2 oblique septatis.

SPECIMEN EXAMINED: **BRAZIL. DISTRITO FEDERAL:** PLANALTINA, Estação Ecológica de Águas Emendadas, on living leaves of *Pseudobombax* sp. (*Bombacaceae*), 27 Feb 1997, *leg. M. Sanchez* 2345, **holotype** (UB mycol. col. 13558).

LESIONS irregular, sometimes angular, amphigenous, brown, without a well-defined margin, 1–14 mm diam., sometimes coalescent reaching up to 5.5 cm diam. COLONIES amphigenous, caespitose, dark brown or black, scattered on lesions, erumpent or stomatal. MYCELIUM immersed in the substrate. STROMATA poorly developed. CONIDIOPHORES loosely fasciculate, lageniform or ampulliform and without septa when young, cylindrical, lageniform and 1–5-septate when mature, straight or flexuous, smooth, geniculate, sometimes sympodially proliferating, 35–55 μm long, 2–4 μm at the apex, 6–8 μm diam. close to the apex, 7–12 μm at the base, light yellowish green to olivaceous. CONIDIOGENOUS CELLS integrate, terminal, polyblastic, sympodial, geniculate; conidiogenous loci inconspicuous, neither thickened nor pigmented. CONIDIA solitary, straight, curved or flexuous, obclavate, truncate to obconically truncate at the base, rounded at the apex, sometimes with a constriction near the base; light green or yellowish green, paler at the apex, sometimes more intensely pigmented, up to olivaceous, and thick-walled, except for the lighter basal and apical cells, 27–95 μm long, 5–9 μm diam. at the widest part, 2–4 μm at the base, 3–5 μm at the apex, with 1–14 transverse and 1–2 oblique septa, smooth.

COMMENTS: This fungus has some characteristics of *Prathigada* Subram. species (thick and dark conidial walls and septa) but the conidiogenous loci

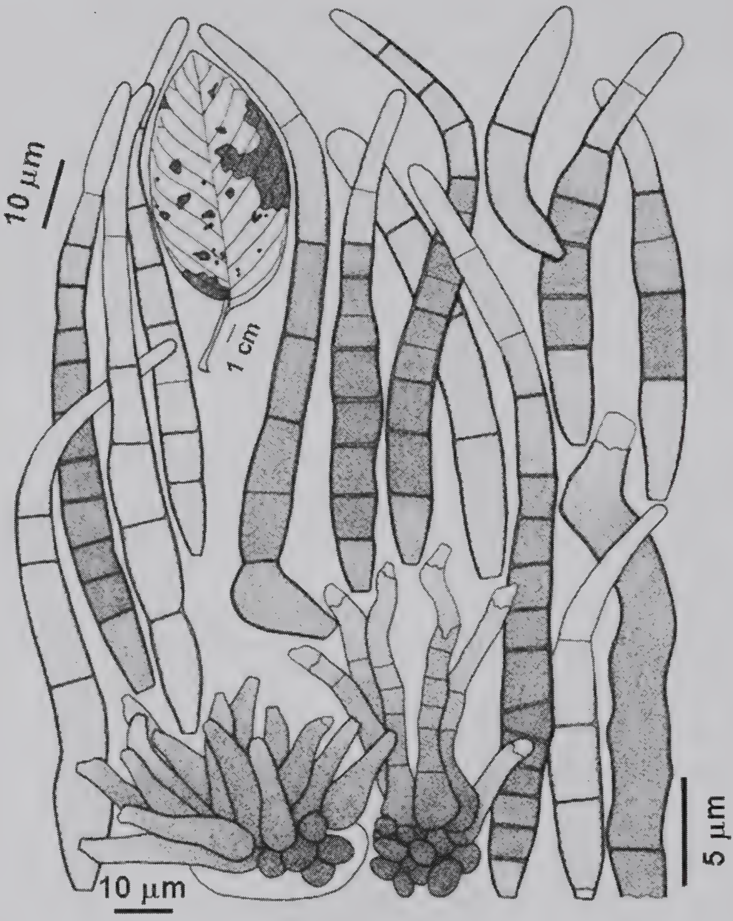

Fig. 5. *Pseudocercospora pseudobombacis* on *Pseudobombax* sp. Coalescent brown lesions on a leaf (top left); conidia with thick walls and septa similar to those of *Prathigada* species; sympodially proliferating septate conidiophores with conidiogenous cells showing unthickened conidiogenous loci. Based on the holotype (UB Mycol. Col. 13558).

are inconspicuous as in *Pseudocercospora* species, so that this species has to be placed in the latter genus. Several species of *Pseudocercospora* on hosts of the *Bombacaceae* are known, but *P. bombacina, P. eriodendri*, and *P. pachirae* are easily distinguishable from *P. pseudobombacis* by their shorter and above all much narrower, thin-walled conidia with few, always transverse septa (Chupp 1954, Vasudeva 1963).

Pseudocercospora eriothecae A. Hern.-Gut. & Dianese, **sp. nov.** FIG. 6
MYCOBANK, MB 512040

Differt a Pseudocercospora bombacina, P. eriodendri et P. pachirae conidiophoris aeque brevibus et conidiis distincte septatis, rectis vel leviter curvatis.

SPECIMEN EXAMINED. BRAZIL. MINAS GERAIS: DIVINÓPOLIS, Feira Agropecuária, on living leaves of *Eriotheca* sp., (*Bombacaceae*), 26 Jun 1995, *leg. JC Dianese* 2420, **holotype** (UB mycol. col. 9079).

LESIONS 1–14 mm diam., amphigenous, irregular, coalescent, brown, surrounded by a darker halo. COLONIES epiphyllous, grayish, scattered on the lesions. MYCELIUM immersed. STROMATA well-developed, subcuticular or immersed in the epidermis, 12–42 μm diam., mixed texture (*textura globosa* and *angularis*), brown. CONIDIOPHORES in small, loose fascicles, shape variable, unbranched, 10–59 × 3–5 μm, pale brown, thin-walled, smooth, 0–2-septate, sometimes reduced to conidiogenous cells; comprising three types, depending on the state of development: a) short conidiophores – lageniform, 10–17 μm long, 3–5 μm diam. at the widest part, 1–2 μm at the apex, aseptate (conidiophores reduced to conidiogenous cells), sometimes sympodially proliferated; b) medium conidiophores – lageniform to cylindrical, straight or slightly curved, pale brown, 17–30 μm long, 3–4 μm diam. at the widest part, 1–2 μm diam. at the apex, 0–2-septate, with a single sympodial proliferation; c) long conidiophores – cylindrical, straight, pale brown, smooth, flexuous or curved, 31–59 μm long, 3–3.5 μm diam. at the widest part, 1–3-septate, sympodial proliferations with up to three geniculations per conidiophore. CONIDIOGENOUS CELLS integrated, terminal, conidiogenous loci inconspicuous. CONIDIA solitary, straight, flexuous or curved, sometimes reaching almost 90° just below the second basal septum, cylindrical or slightly obclavate, truncate at the base and rounded at the apex, 27–63 μm long, 2–3 μm diam. at the widest part, 1–2 μm near the apex and at the base, sparsely and obscurely 0–6-septate, subhyaline, smooth, thin-walled.

COMMENT: *Pseudocercospora eriothecae* is quite distinct from *P. pseudobombacis*, described above, by its much narrower conidiophores and conidia with few, consistently transverse septa. *Pseudocercospora bombacina, P. eriodendri* and *P. pachirae* are similar, but possess uniformly short conidiophores and straight to only somewhat curved conidia with conspicuous septa (Chupp 1954, Vasudeva 1963).

Cercosporoid fungi on *Burseraceae*

Twenty plant genera of tropical distribution belong in the family *Burseraceae*, with three genera present in the Cerrado: *Commiphora*, *Protium* and *Tetragastris*, with a total of 12 species, seven of them belonging in *Protium* (Mendonça et al. 1998). Silva & Minter (1995) listed 109 fungal species on hosts

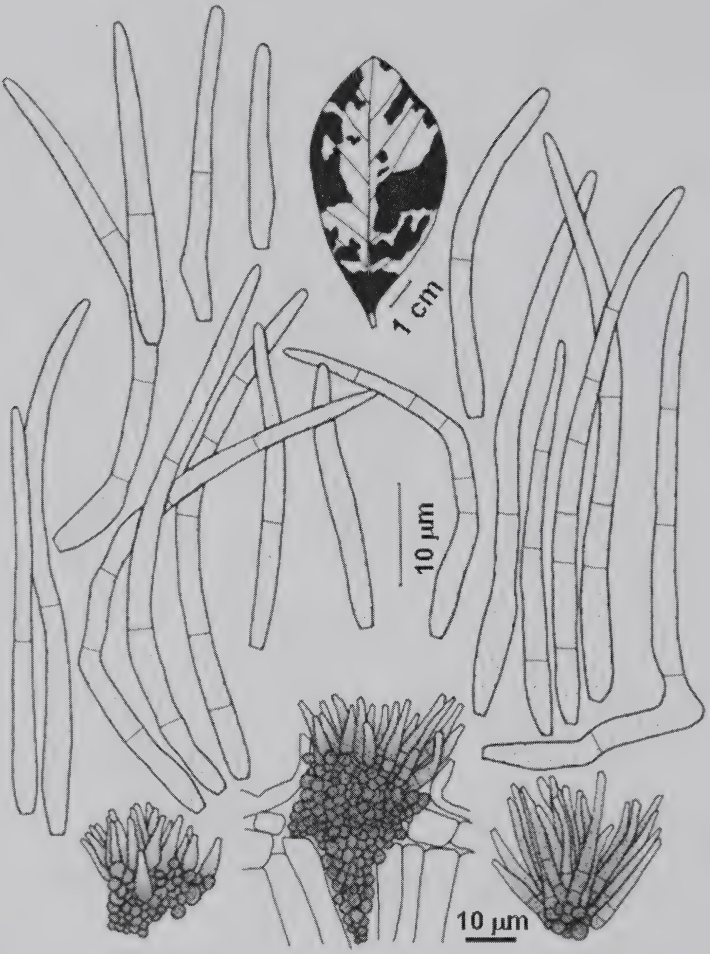

Fig. 6. *Pseudocercospora eriothecae* on *Eriotheca* sp. Scattered black lesions on a leaf (top center) among conidia with truncate, thin hila; erumpent stromata with *textura globosa,* bearing conidiophores and conidiogenous cells with inconspicuous, flat conidiogenous loci. Based on the holotype (UB Mycol. Col. 9079).

of the *Burseraceae*, among them 80 species occurring on species of *Garuga* and *Protium*, including 24 hyphomycetes, but none of them belonging to the *Cercospora* complex. Dianese et al. (1997) listed for the Cerrado nine species of ascomycetes and four hyphomycetes, all of them occurring on *Protium* sp. Few cercosporoid species have been described from hosts of this plant familiy, viz. the Indian *Cercospora boswelliae* Harsh et al. on *Boswellia serrata* Roxb. ex Colebr., *C. burserae* Govindu & Thirum. on *Bursera delpechiana* (DC.) Engl., and *C. garuaicola* Narayan et al. and *Stenella garugae* J. M. Yen et al. on *Garuga pinnata* Roxb. (Yen et al. 1982, Crous & Braun 2003). The following new species represents the first member of the genus *Pseudocercospora* on a host of the *Burseraceae.*

Pseudocercospora protii A. Hern.-Gut. & Dianese, **sp. nov.** FIG. 7
MYCOBANK, MB 512041

Laesiones 5–10 mm diam., amphigenae, orbiculares, angulares vel irregulares, adaxiale griseolae, margine brunneo-rubricoso cinctae, abaxiale brunneae, sine margine distincto. Coloniae amphigenae, punctiformes. Stromata 60–140 μm diam. ex texturis intermixtis globosis et angularis, bene evoluta, subepidermalia, erumpentia, brunnea. Conidiophora in fasciculis compactis aggregatis, recta, curvata vel flexuosa, cylindrica, 57–80 μm longa, 4–5 μm lata in parte latissima, 3–6-septata, brunneo-olivacea, apicem versus pallidiora. Cellulae conidiogenae in conidiophoris incorporatae, terminales, praecipue monoblasticae, aliquando polyblasticae, sympodiales; cicatricibus inconspicuis. Conidia solitaria, filiformia vel anguste obclavata, curvata, subhyalina, guttulata, basi obconico-truncata, hilo tenui claro, apice obtuso vel acuto, 55–201 μm longa, 2–3 μm lata in parte latissima, 1–2 μm lata ad basem, 1–1.5 μm lata prope apicem, 5–10-septata, laevia.

SPECIMEN EXAMINED: **BRAZIL. GOIÁS:** CRISTALINA, Fazenda Nova Índia, on living leaves of *Protium ovatum* (*Burseraceae*), 10 Apr 1993, *leg. JC Dianese* 831, **holotype** (UB mycol. col. 3739).

LESIONS amphigenous, circular, angular or irregular, gray, with a reddish brown halo on the adaxial surface, brown and without halo on the abaxial surface. COLONIES amphigenous, punctiform, brown. STROMATA subepidermal, well-developed, 60–140 μm diam., mixed *textura globosa* and *angularis*, erumpent, brown. CONIDIOPHORES densely fasciculate, numerous, straight, curved or flexuous, cylindrical, 57–80 μm long, 4–5 μm diam. at the widest part, 3–6-septate, brown-olivaceous, paler towards the apex, thin-walled, smooth. CONIDIOGENOUS CELLS integrate, terminal, mainly monoblastic, occasionally polyblastic, sympodial. CONIDIOGENOUS LOCI inconspicuous, neither thickened nor pigmented. CONIDIA solitary, filiform to narrowly obclavate, curved, subhyaline, guttulate, obconically truncate at the base, obtuse to acute at the apex, 55–201 μm long, 2–3 μm diam. at the widest part, 1–2 μm at the base, 1–1.5 μm near the apex, 5–10-septate, smooth, thin-walled, hilum unthickened, not darkened.

Cercosporoid fungi on *Celastraceae*

The family *Celastraceae* has about 60 genera worldwide, mainly in the tropics and subtropics. The most frequent genera in the Cerrado are *Maytenus* with 12 species, *Austroplenckia* with only one species [*A. populnea* (Reissek) Lundell] and *Tontelea* with 15 species (Mendonça et al. 1998). Numerous cercosporoid

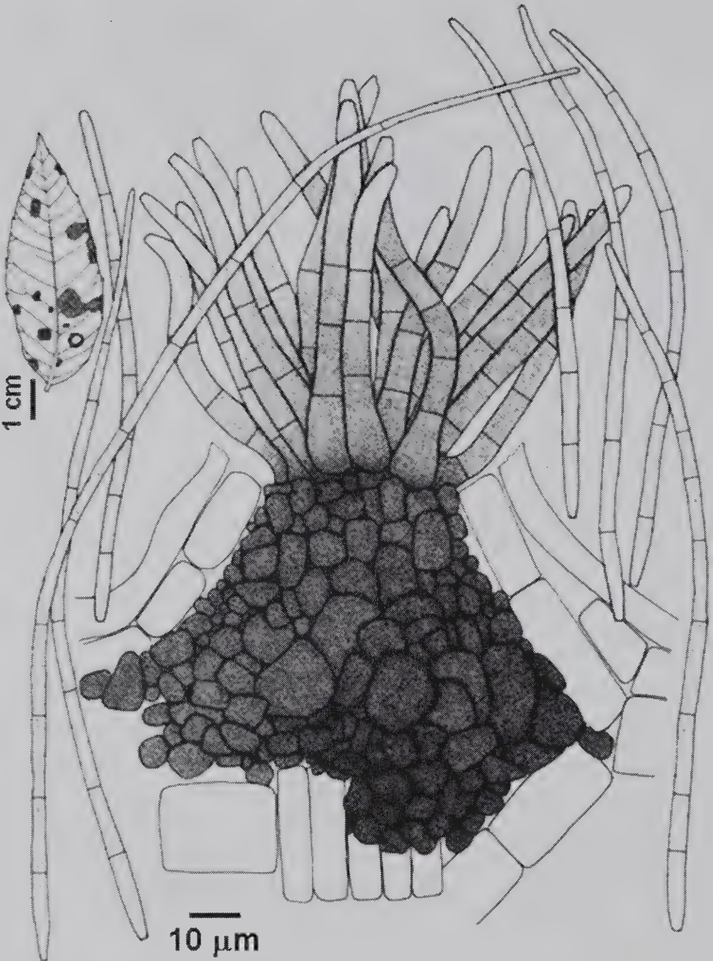

Fig. 7. *Pseudocercospora protii* on *Protium ovatum*. Brown coalescent lesions on a leaf (top left); subepidermal erumpent stroma with *textura angularis* bearing septate conidiophores and conidiogenous cells without conspicuous conidiogenous loci; conidia pluriseptate pale brown. Based on the holotype (UB Mycol. Col. 3739).

hyphomycete species have been described on hosts belonging to the *Celastraceae*, e.g. *Cercospora celastricola* Govindu & Thirum., *C. euonymigena* Y.L. Guo & Y. Jiang, *Cercosporella euonymi* Erikss. (= *Cercospora euonymi* Ellis), *Mycocentrospora verrucosa* Pollack & Ellett, *Passalora melanochaeta* (Ellis & Everh.) U. Braun, *Pseudocercospora celastri* S. Singh, *P. elaeodendri*

(G.P. Agarwal & Hasija) Deighton, *P. destructiva* (Ravenel) Y.L. Guo & X.J. Liu, *P. gymnosporiae* R.K. Dubey et al., *P. myricacearum* M.K. Khan et al., *P. paradoxa* U. Braun & Bagyan., *Pseudocercosporella gymnosporiae* Bagyan. et al.., *Ramularia celastri* Ellis & G. Martin, *Stenella celastri* A.N. Rai & Kamal, *S. elaeodendri* Kamal et al., *S. hippocratiae* K. Srivast. et al., *Verrucisporota indica* (Kamal & P. Kumar) U. Braun (Chupp 1954, Deighton 1976, Singh 1979, Dubey et al. 1990, Rai & Kamal 1990, Khan et al. 1991, Guo & Hsieh 1995, Braun 1995, 1998, Bagyanarayana & Braun 1999, Crous & Braun 2003). Dianese et al. (1997) mentioned an ascomycetous species and a non-cercosporoid hyphomycete occurring on *Austroplenckia* sp., while Silva & Minter (1995) listed 24 ascomycetous species and 19 non-cercosporoid hyphomycetes associated with hosts of the family *Celastraceae*.

Two new cercosporoid hyphomycetes have recently been found on *A. populnea* in the Cerrado, including one belonging in *Pseudocercospora* and a second species which represents the first member of *Prathigada* on a host of the *Celastraceae*.

Prathigada austroplenckiae A. Hern.-Gut. & Dianese, **sp. nov.** FIG. 8

MYCOBANK, MB 512042

Differt a omnibus speciebus generis conidiophoris ex cellulis stromaticis cylindraceis oriundis et cicatricibus valde protuberantibus et fuscatis.

SPECIMEN EXAMINED: BRAZIL. DISTRITO FEDERAL: BRASÍLIA, Centro Olímpico da Universidade de Brasília, on living leaves of *Austroplenckia polpunea* (*Celastraceae*), 26 Aug 1994, *leg. C.A. Inácio* 8, **holotype** (UB mycol. col. 17810); 11 May 1994, *leg. C.A. Inácio* 114, **paratype** (UB mycol. col. 6109).

LESIONS amphigenous, 1–3 mm diam., circular to elliptical, dispersed or aggregated and coalescent to form lesions of up to 30 mm diam., dark brown. COLONIES amphigenous, orange-brown, subcuticular or subepidermal, erumpent. *Stromata* well-developed, *textura globosa*, 30–52 µm diam. CONIDIOPHORES arising from cylindrical stromatic cells, caespitose, straight, flexuous or curved, lageniform, aseptate and with a single apical scar when young or cylindrical, 1–4-septate, 23–40 µm long, 4–7 µm diam. in the widest part, with enteroblastic rejuvenation (monopodial growth by rupture of the apical region). CONIDIOGENOUS CELLS integrated, terminal, polyblastic, sympodial, strongly cicatrized, with 1–30 darkened, thickened, strongly protuberant conidiogenous loci. CONIDIA solitary, simple, obclavate, sometimes rostrate, truncate to obconically truncate at the base with a prominent, thickened, darkened hilum, straight, flexuous, cylindrical to obclavate, 34–92 µm long, 5–7 µm diam. at the widest part, 2–3 µm at the base, 2–4 µm at the light brown, rounded apex, 0–14-septate, septa and walls thick and dark, smooth or sometimes finely verruculose.

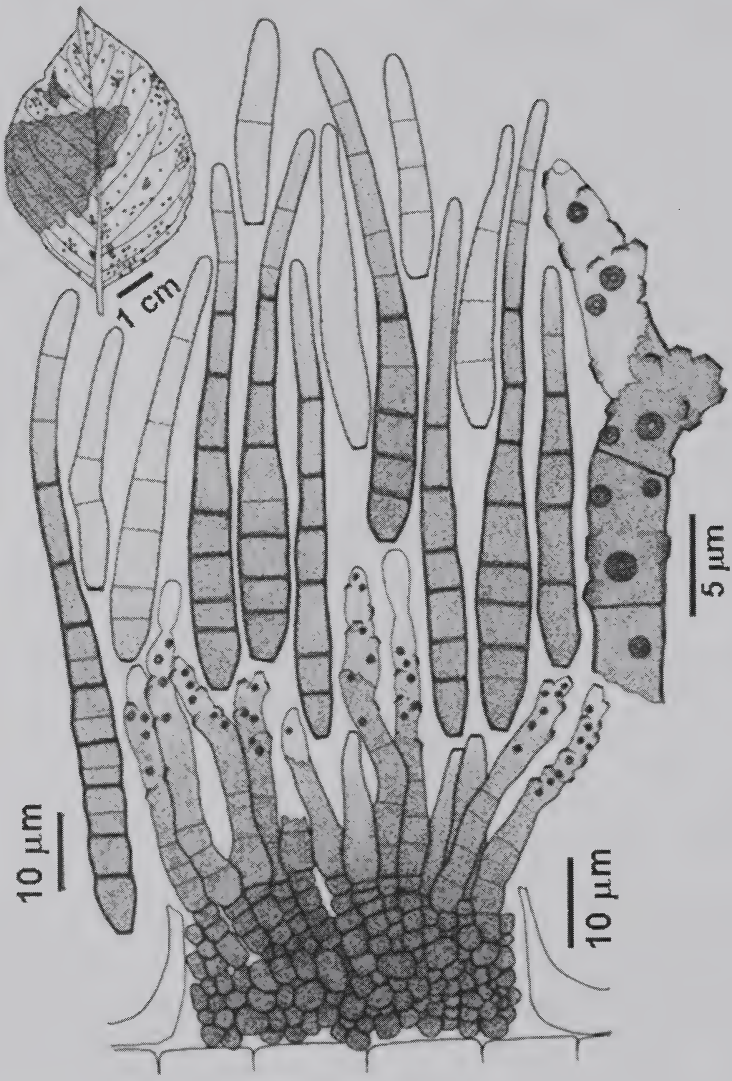

Fig. 8. *Prathigada austroplenckiae* on *Austroplenckia populnea.* Leaf with small lesions that may coalesce (top left); conidia with thick, dark walls, septa, and hilum; conidiophores sympodial, septate, with condiogenous cells strongly cicatrized with dark conidiogenous loci; subcuticular erumpent stroma with *textura angularis*. Based on the holotype (UB Mycol. Col. 17810).

COMMENT: This species has in common with the type species, *Prathigada crataevae* (Syd.) Subram. (Subramanian & Ramakrishnan 1956), the presence of subcuticular, well-developed stromata, sympodial conidiogenous cells and sometimes rostrate conidia. However, the new species differs in possessing conidiogenous loci more prominent than described in the type species, and profusely geniculate conidiophores. These characteristics are also present in *P. terminaliae* (Syd.) B. Sutton (Sutton 1994), but in this species the conidiogenous loci are just slightly protuberant and the geniculations are less distinct. Moderately protuberant loci are also present in *P. maclurae* (Thüm.) U. Braun (Braun 1996). Geniculate conidiogenous cells and slightly thickened scars also occur in *P. backmanii* Furlan. & Dianese (Furlanetto & Dianese 1999). In general, conidia of all known *Prathigada* species are obclavate to subcylindrical or fusiform, with some thick septa and thick cell walls. Three species (*P. crataevae*, *P. maclurae* and *P. terminaliae*) have in common with the new *P. austroplenckiae* the presence of slightly rostrate and verruculose conidia, but stromata are absent or only small. However, the two main distinguishing characters are the very dark protuberant scars on the conidiogenous cells, and the presence of columns of almost cylindrical stromatic cells giving rise to the conidiophores. These characters are not present in the species mentioned above, as well as in all other previously known species, including *P. bauhiniae* P. Rama Rao, P. Rag. Rao & Manohar. (Rao & Manoharachary 1975), *P. condensata* (Ellis & Kellerm.) U. Braun (Braun 1999), *P. gymnocladii* (Ellis & Kellerm.) U. Braun (Braun 1996), *P. punjabensis* (Subram.) Subram., *P. tamarindi* Muthappa (Muthappa 1965) and in *P. zizyphi* A.V. Rao & K. Ramakr. (Rao & Ramakrishnan 1965).

Pseudocercospora austroplenckiae A. Hern.-Gut. & Dianese, **sp. nov.** FIG. 9

MYCOBANK, MB 512043

Laesiones parvae, 1–3 mm diam., amphigenae, orbiculatae, ellipticae, dispersae vel aggregatae, coalescentes, usque ad 30 mm diam., atro-brunneae. Coloniae hypophyllae, nigrae, nitidae, sparsae. Stromata 20–30 µm diam., e texturis globosis, parva, rudimentalia, substomatalia. Conidiophora in fasciculis laxis aggregata, brevia, unicellularia, lageniformia, ampulliformia, laevia, olivacea, tenuitunicata, 10–17 µm longa, 3–7 µm lata in parte latissima, 1–2 µm lata prope apicem, vel conidiophora solitaria ex hyphis superficialibus oriunda, cylindrica vel doliiformia-lageniformia, apice truncato, 6–13 µm longa. Cellulae conidiogenae integratae, terminales, monoblasticae, aliquando sympodiales; cicatricibus inconspicuis, non incrassatis, non fuscatis. Conidia solitaria, simplicia,, recta, curvata vel leviter flexuosa, cylindrica, obclavata, basi truncata vel obconico-truncata, apice rotundato vel leviter acutato, 16–66 µm longa, 2–4 µm lata in parte latissima, 1–2 µm lata ad basem et prope apicem, obscure 0–6-septata, olivacea, laevia, tenuitunicata.

SPECIMEN EXAMINED: BRAZIL. DISTRITO FEDERAL: BRASÍLIA, Centro Olímpico da Universidade de Brasília on living leaves of *Austroplenckia polpunea* (*Celastraceae*), 26 Aug 1994, *leg. C.A. Inácio* 8, **holotype** (UB mycol. col. 1189).

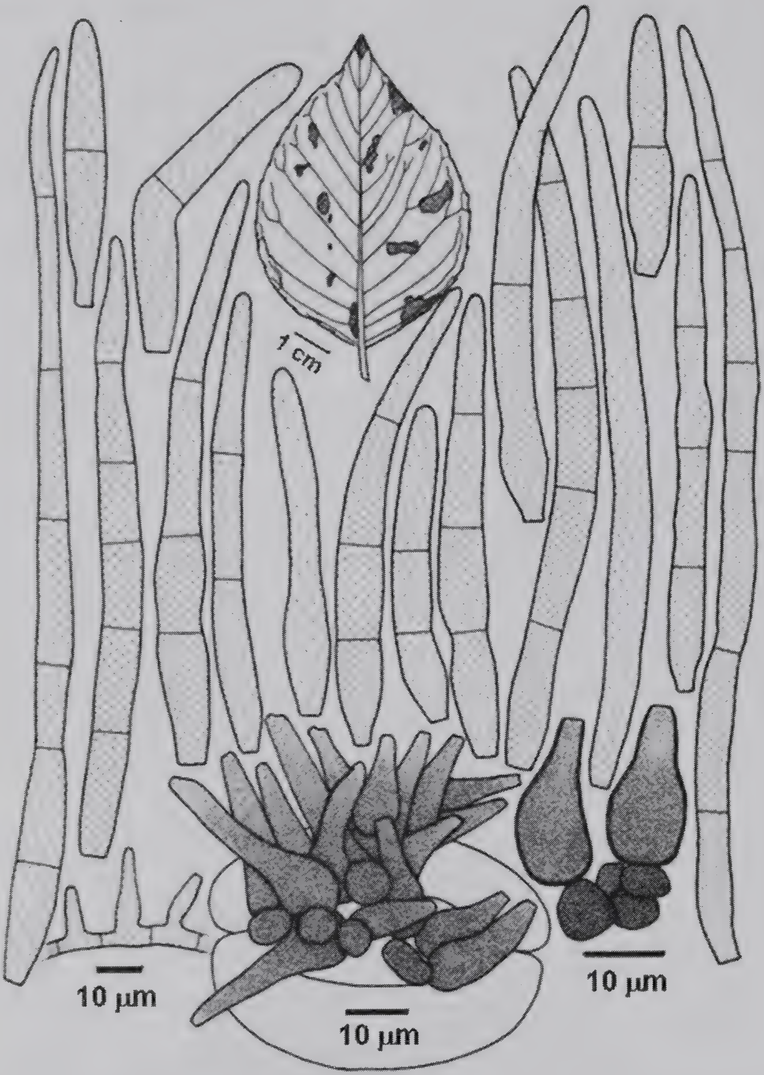

Fig. 9. *Pseudocercospora austroplenckiae* on *Austroplenckia populnea.* Leaf showing brown irregular lesions; conidia obclavate, with thin septa and wall; fascicle of conidiogenous cells arising from a substomatal stroma; superficial hypha with conidiogenous cells. Based on the holotype (UB Mycol. Col. 1189).

Lesions mostly small, 1–3 mm diam., amphigenous, circular, elliptical, irregular, dispersed or aggregated, confluent, reaching up to 10 mm diam., dark brown. Colonies hypophyllous, shiny black, sparse. Stromata poorly developed, 20–30 µm diam., *textura globosa*, substomatal. CONIDIOPHORES caespitose as well as solitary, fasciculate conidiophores short, reduced to conidiogenous cells, lageniform, ampulliform, emerging through stomata, olivaceous, smooth, thin-walled, 10–17 µm long, 3–7 µm diam. in the widest part, 1–2 µm near the apex; solitary conidiophores laterally arising from superficial hyphae, cylindrical or doliiform-lageniform, truncate at the apex, 6–13 µm long. CONIDIOGENOUS CELLS sometimes sympodially proliferating, conidiogenous loci inconspicuous. CONIDIA solitary, simple, straight, curved or slightly flexuous, cylindrical, obclavate, truncate to obconically truncate at the base, rounded to slightly acute at the apex, olivaceous, 16–66 µm long, 2–4 µm diam. at the widest part, 1–2 µm at the base and near the apex, 0–6-septate, but septa rather obscure, smooth, thin-walled, hila neither thickened nor darkened.

COMMENT: Several *Pseudocercospora* species are known on hosts of the *Celastraceae*, e.g. *P. celastri, P. destructiva, P. elaeodendri, P. gymnosporiae* and *P. myricacearum* (Chupp 1954, Deighton 1976, Singh 1979, Dubey et al. 1990, Khan et al. 1991, Guo & Hsieh 1995), but all of them are characterized by having well-developed stromata, much longer, septate conidiophores and lacking superficial mycelium and solitary conidiophores. *Pseudocercospora austroplenckiae* is distinguished from these species by its poorly developed substomatal stromata and aseptate conidiophores, either fasciculate or solitary, arising from superficial hyphae. Furthermore, *P. celastri* and *P. gymnosporiae* possess much wider conidia, 2.5–10 µm. The Indian *P. paradoxa* (Bagyanarayana & Braun 1999) described from *Elaeodendron* sp., forms superficial hyphae, but is quite distinct by having consistently solitary conidiophores, arising from the superficial hyphae, up to 200 µm long and 3–7 µm wide, pluriseptate, and broad conidia, 15–55 × 4–8 µm, occasionally with 1–2 longitudinal or oblique septa.

Acknowledgments

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MYCOTAXON

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Checklists of the myxomycetes, larger ascomycetes, and larger basidiomycetes in Turkey

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Abstract—This paper provides a compilation of available data on the myxomycetes, larger ascomycetes, and larger basidiomycetes reported from or known to occur in Turkey. Three main lists of correct names of myxomycetes, larger ascomycetes, and larger basidiomycetes, recognized as occurring in Turkey, are given, in which the taxa are alphabetically arranged. For each taxon, references are cited. An index of synonyms based on literature records from Turkey is appended. A list of excluded records, providing reasons for their exclusion, is also given. The complete checklists are available on: http://www.mycotaxon.com/.

Key words—biodiversity, fungal diversity, macrofungi, Turkish mycota

Introduction

A number of studies on the mycota of Turkey (Fig. 1) have been published. Contemporary knowledge on the diversity of Turkish myxomycetes and macrofungi is based on a period of more than 90 years of investigations. In the course of gathering literature sources, we found more than 400 scientific works, which contain various Turkish records of myxomycetes and macrofungi. During the 1990s and part of the first decade of 2000, the accumulation of a huge number of records, without a published catalogue of the macrofungi in Turkey, allowed room for many mistakes, including duplication of errors in some articles concerning new Turkish records. In the past, some species were published as new records many times and in different years by the same or different authors, and in the same or different journals.

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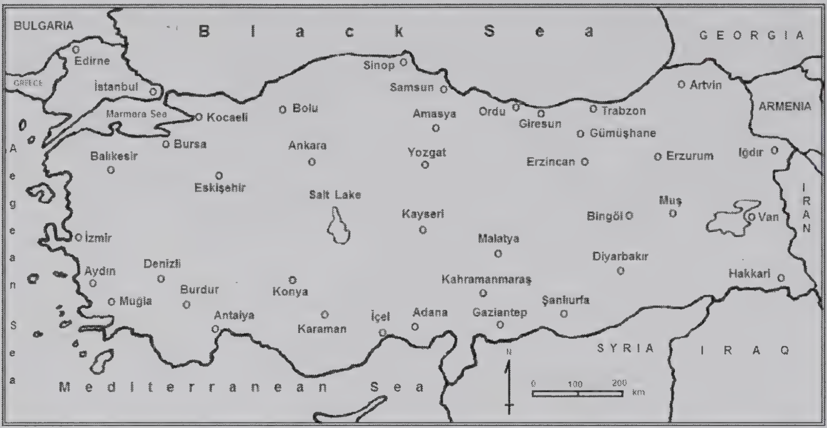
BULGARIA
Black Sea
GEORGIA
Edirne
GREECE
İstanbul
Marmara Sea
Kocaeli
Bolu
Sinop
Samsun
Amasya
Ordu
Giresun
Trabzon
Artvin
ARMENIA
Gümüşhane
Bursa
Balıkesir
Ankara
Yozgat
Erzincan
Erzurum
Iğdır
Eskişehir
Salt Lake
Kayseri
Bingöl
Muş
Van
IRAN
Aegean Sea
İzmir
Malatya
Diyarbakır
Aydın
Denizli
Kahramanmaraş
Hakkari
Muğla
Burdur
Konya
Şanlıurfa
Antalya
Karaman
İçel
Adana
Gaziantep
SYRIA
IRAQ
Mediterranean Sea
N
0 100 200 km

Fig. 1. Neighbouring countries and some of the major cities of Turkey

The first contribution to the macrofungi from Turkey was published by K. Vlaev (1915). Sesli & Baydar (1995, 1996) presented the first checklists of macrofungi, including *Russulaceae* and *Agaricales*, respectively. The first checklist of myxomycetes was compiled by Ergül & Dülger (2000). Sesli & Denchev (2005) published a checklist of myxomycetes and the first complete checklist of Turkish macrofungi and their synonyms. Additional checklists of myxomycetes (Dülger 2007) and macrofungi (Solak et al. 2007) have recently appeared.

The aim of this new edition of the checklists is a further attempt to summarize and completely present the correct names of species of myxomycetes, larger ascomycetes, and larger basidiomycetes currently known in Turkey, as well as to list their synonymous names occurring in the available sources on the fungi in Turkey. We hope that this paper will be a guide for future studies and a helpful source for creation of a database of the Turkish mycota.

We intend to update regularly the Internet version of the checklists.

Materials and methods

Main lists of myxomycetes, larger ascomycetes, and larger basidiomycetes have been developed. The taxa are given in alphabetical order. The numbers within square brackets, following the authors of each species or infraspecific taxon, refer to the reference(s) where the taxon is reported. A number [001–288] and letters (e.g., a, b, c) are assigned to each reference in the section "Bibliography of the contributions to myxomycetes, larger ascomycetes, and larger basidiomycetes in Turkey". The generic and species treatment follows many of the recent monographs and particular articles on the European fungi. The names of authors of fungal taxa are abbreviated according to Kirk & Ansell (1992) and Kirk et al. (2004).

Because many species have been published under different names, a thesaurus of synonyms is separately listed with references to the correct names used in the main lists. A list of excluded records, providing reasons for their exclusion, is also appended.

Results

The complete checklists and estimation of the species, recognized as occurring in Turkey, are available on: http://www.mycotaxon.com/. We envisage the Internet version of the checklists to be regularly updated.

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Comatricha argentinae, a synonym of *C. tenerrima*

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Abstract — The type material of *Comatricha argentinae* was studied. The type is the only known collection of this species, which was described from Argentina. Sporocarp morphology and the typical spore ornamentation under SEM coincide with those of *C. tenerrima*. Thus, the synonymy of these species is proposed. Light microscope images of sporocarps and capillitium along with scanning electron microscope photographs of spore ornamentation are presented.

Key words — *Myxomycetes, Stemonitales*, taxonomy

Introduction

Comatricha argentinae is a species known only from its original description. It was proposed as new to science by Deschamps (1974), based on a collection from the decaying wood of *Ulmus procera*. In the original publication, the species is described as *Comatricha 'argentina.'* Later, Lado (2001) corrected the name to *Comatricha argentinae*. According to the GBIF (www.gbif.net) data base, no other records are known worldwide.

The first description included black and white drawings of the sporocarps, which are similar to those of a number of other species of *Comatricha*. Line drawings of the spores and capillitium were also included. Although the capillitium is described as flat and provided with warts or rings, this appears to be an unusual type of ornamentation for the genus. This is the reason why we believed *Comatricha argentinae* needed detailed investigation by electron microscopy.

Materials and Methods

The type material studied is located in the Herbarium of the Department of Plant Biology, University of Alcalá, Madrid, Spain (AH).

The sporocarps studied were mounted in Hoyer's medium. Spores were measured to include surface structures such as spines or warts and measurements were made with an oil immersion lens. For ultramicroscopic studies, the material to be examined was rehydrated in concentrated ammonium hydroxide (28–30%) for 30 minutes, dehydrated in aqueous ethanol (70%) for 30 minutes, fixed for 2 hours in pure ethylene glycol dimethyl ether (= 1,2–dimethoxymethane) and finally immersed in pure acetone for at least 2 hours. This was followed by critical point drying and sputtering with gold-palladium.

The micrographs were taken at the University of Alcalá using a Zeiss DSM–950 microscope. The technique followed requires the use of very little material (one sporocarp, a part of it or only a small portion of spores). Terminology used herein to describe spore ornamentation follows that of Rammeloo (1975a, b).

Description

Comatricha argentinae J.R. Deschamps, Bol. Soc. Argent. Bot. 15(4): 340 (1974)

Figs. 1-7

Fructificationes solitariae vel gregariae ex hypotalum minutum badium fulgidae conspiquum surgentes. Esporamgia castanea, elliptico-ovoidea vel globosa, superne attenuata, 0.3–0.6 × 0.5–1.2 mm, peridio obscuriore, plerunque evanescente sed in base esporangii persistente et calyculo circulare castaneo-rufescente simulante. Pes nigrescens vel badius opacus, subulatus, cavus, longitudinaliter substriatus quam espongium 2-3 vices longior. Columnella plerunque exserta, ¾ partibus longitudinis vel toto sporangio occupandum, percurrens badia, apice leviter ramosa et in filiis tenuibus desinentia capillicíum formans. Capillitium ex columnella vel raro ex calyculo surgente evanescente plerunque ramosum cavum 1–4 µm diam., laeve vel cum verrucis annulisve ornatum, pallíde castaneum. Esporarum massae pallíde badiae, globosae, verrucosae, conspicuae (6–)6.6–7.7(–8) µm diam, Plasmodium ignotum.

Holotypus — *Argentina,* Buenos Aires, Llavallol, Instituto Fitotécnico de Santa Catalina, *leg.* L. Frías & G. Rovetta, 5-X-1970 (BAFC 22868 holotype), (LPS 37739 isotype), (BPI isotype).

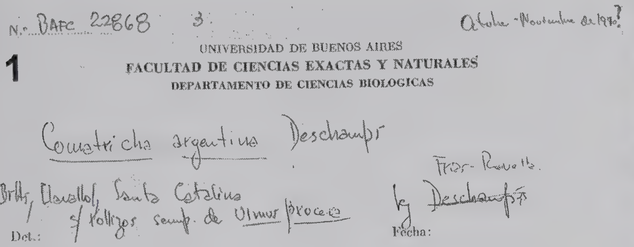
Habitat — On decaying *Ulmus procera* wood, after frequent rain.

Examined Material — Material type BAFC 22868 is stored as AH 31762, along with a Hoyer's medium preparation.

The type material is stored in a match box with three pieces of wood of various sizes glued to its the base. A card which has only three stalks and two columellae and no capillitium or spores is stuck to the bottom of the box. The specimen is very sparse, consisting of few complete sporocarps, some of which are very hardened (Fig. 3), and only the stalks of some are preserved. However, a single mature sporocarp (Fig. 4) was available for study of its morphology and spore ornamentation under MO and SEM (Figs. 6-7).

Due to the impossibility of compiling a complete macroscopic description of this species, the detailed description published by Deschamps (1974) is translated

1



N.° BAFC 22868   3   Octubre - Noviembre de 1970?

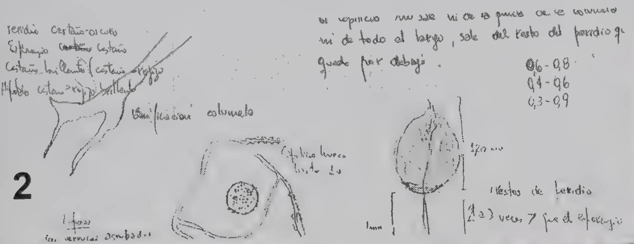
UNIVERSIDAD DE BUENOS AIRES
FACULTAD DE CIENCIAS EXACTAS Y NATURALES
DEPARTAMENTO DE CIENCIAS BIOLOGICAS

Comatricha argentina Deschamps

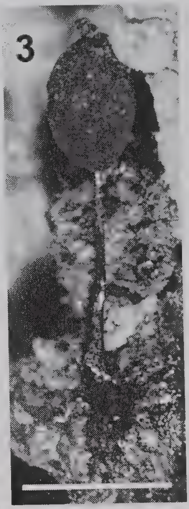
Bs As, Llavallol, Santa Catalina
s/ rollizos semp. de Ulmus procera   Fras. Ravetti
leg. Deschamps

Det.:   Fecha:

2


peridio castaño-oscuro
Esporangio ~~castaño~~ castaño
Castaño brillante (castaño rojizo)
Hipotalo castaño rojizo brillante
Ramificación columela
el capilicio no sale ni de la punta de la columela ni de todo el largo, sale del resto del peridio q. queda por debajo.
0,6 - 0,8
0,4 - 0,6
0,3 - 0,9
Capilicio hueco hasta ...
esporas con verrugas agrupadas
120 µm
restos de peridio
(1-2) veces > que el esporangio
1 mm

3



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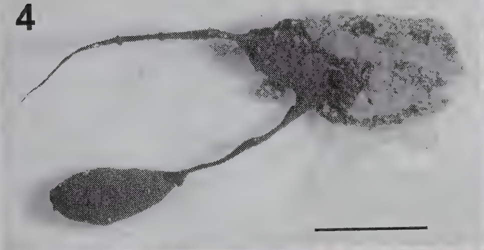

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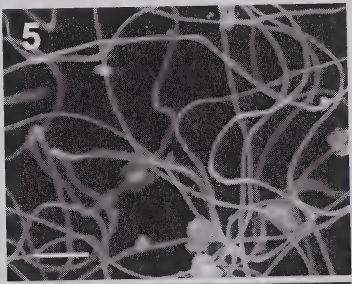

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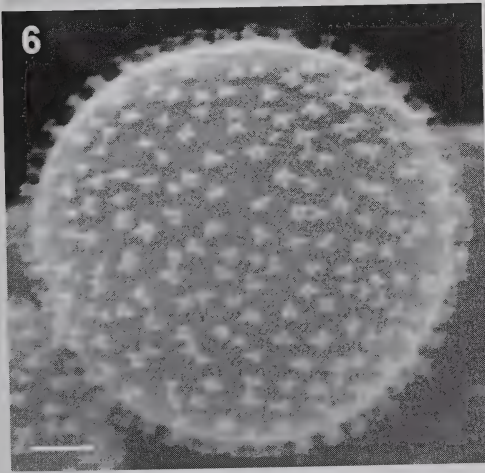

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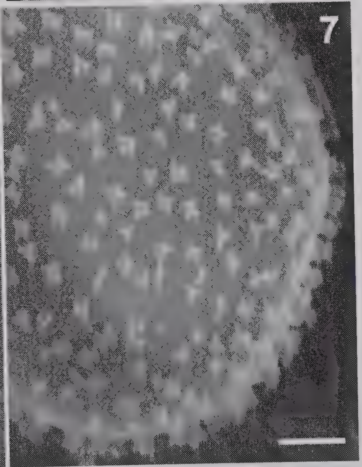

FIGS. 1-7 *Comatricha argentinae* (holotype BAFC 22868): 1. Original label. 2. Drawings kept with the type sample. 3. Hardened sporocarp. 4. Mature sporocarp. 5. Spore. 6. Detail of spore ornamentation. SCALE BARS. 3-4 = 1 mm. 5-6 = 1 µm.

as follows: "Solitary fructifications or in gregarious groups, appearing from a small hypothallus, dark brown reddish, shiny, conspicuous. Brown sporangia, elliptical-ovoid to spherical with the superior region (apex) slightly thinner due to the inner presence of the columella, which frequently protrudes from the tip of the sporotheca, 0.3–0.6 × 0.5–1.2 mm with a darker peridium, usually evanescent, but persisting at the base of the sporotheca as a circular calyculus, brown-reddish by transparency. Blackish to dark brown stalk, opaque, subulate, hollow, somewhat striated lengthways, 2–3 times the length of the sporotheca. Columella occupying all the sporotheca or up to ¾ of its length, percurrent, dark reddish brown, branching slightly at the extremities and producing thin threads which form the capillitium. Capillitium arising from the columella and, in some cases, the calyculus, evanescent, frequently branched, hollow, 1–4 µm diameter, flat or ornamented with warts or rings, light brown. Spores brown in mass, light brown reddish under transmitted light, spherical, with conspicuous groups of warts, (6–)6.6–7.7(–8) µm. Unknown plasmodium."

Discussion

Deschamps (1974) stated that *Comatricha argentinae* is similar to *Collaria rubens* (Lister) Nann.-Bremek. (= *Comatricha rubens* Lister), indicating that "this species has got characteristics which are similar to *Comatricha rubens* because of its calyculus and the way the capillitium appears. However, the sporangium's colour, some capillitium details and the spores may indicate that this is a new taxon for science". Deschamps stated that the validity of the new species had been confirmed by M.L. Farr, information that is cited in her monograph (Farr 1976) but without dealing directly with the species, due to the proximity in the time of publication of both investigations.

In a later work, Deschamps (1975) presented a key to the species of *Comatricha* found in Argentina. In this key, he separated *C. rubens* and *C. argentinae* based on sporocarp colour (more reddish in *C. rubens*) and spore ornamentation (slightly spiny in *C. rubens* and with groups of prominent warts in *C. argentinae*). Furthermore, he (Deschamps 1974) had previously indicated that "the columella branching and the capillitium structure place *Comatricha argentinae* near *Lamproderma*."

In our revision of the type, we certainly place the taxon within the genus *Comatricha* because of the sporocarps having a stalk with a fibrous base, a columella that reaches the apex of the sporotheca and the winding branches of the capillitium (Fig. 5), which appear all along the columella and are a somewhat branched. Deschamps (1974) had noted that his species was closely related to *Lamproderma* but evidence for this must inevitably now be refuted.

In our macro-photographs of *Comatricha argentinae* together with those taken under SEM, it can be clearly seen that all the characteristics coincide with *Comatricha tenerrima*, for the following reasons:

1. *Comatricha argentinae* and *C. tenerrima* produce stipitate sporocarps, with a fusiform or ovoid light brown sporotheca.
2. In *Comatricha argentinae* and *C. tenerrima* the columella reaches the apex of the sporocarp and gradually tapers upward. The capillitium is abundant in both species, the branches are all the same in diameter, flexuous, with a flat ornamentation and arise from the whole length of the columella.
3. Under the optical microscope, both species share the same type of spore ornamentation; the spores are warted, with more prominent groups of warts. Under MEB, these warts resemble small baculi with the apex divided into lobes and appearing star-like.

Rammeloo (1981) was the first to study the spore ornamentation of the *Comatricha tenerrima* under MEB, and the latter was described as "très caractéristique pour cette espèce". Later, this ornamentation was confirmed on many occasions by Moreno et al. (1993) and Lizárraga et al. (1999).

Comatricha tenerrima is not the only taxon that has a special spore ornamentation consisting of small baculi with stellate or lobed apices. *Comatricha tenerrima* var. *macrospora* Rammeloo, a taxon known only from the Rwanda Mountains, has a similar spore ornamentation but its sporocarps have longer stalks than those of *C. tenerrima*, possess a peridial collar that subtends the sporotheca and larger spores (Rammeloo 1981, Singer et al. 2006). *Comatricha brachypus* (Meyl.) Meyl., is a similar species with a spore ornamentation consisting of small baculi that fuse to form a pyramid (Singer et al. 2006).

Conclusion

According to the data presented above, we conclude that *Comatricha argentinae* and *C. tenerrima* are two species with identical macro- and microscopic characteristics; therefore, their synonymy is proposed:

Comatricha tenerrima (M.A. Curtis) G. Lister, Guide Brit. Mycetozoa, ed. 4: 39 (1919)

= *C. argentinae* J.R. Deschamps, Bol. Soc. Argent. Bot. 15(4): 340 (1974)

Acknowledgements

We wish to express our gratitude to Dr. S.L. Stephenson and Mr. D.W. Mitchell for reviewing the manuscript and their useful comments and our thanks to Mr. A. Priego and Mr. J.A. Pérez of the Electron Microscopy Service of the University of Alcalá de

Henares for their invaluable help with the SEM. We also thank Luis Monje of the "Gabinete de Dibujo y Fotografía Científica" at the Universidad de Alcalá de Henares for his help in the digital preparation of the photographs, and we are grateful to Dr. J. Rejos, curator of the AH herbarium.

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Additions to the myxomycete biota of Cuba. 1

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Abstract — A study was carried out on the taxonomy and chorology of myxomycetes based on field collections from various localities in Cuba. Some additional collections were obtained from moist chamber cultures. Species recorded for the first time from Cuba were *Calomyxa metallica, Comatricha anomala, Craterium paraguayense, Cribraria confusa, C. macrocarpa, Dictydiaethalium plumbeum, Diderma testaceum, Didymium bahiense, D. difforme, D. nigripes, Licea pedicellata, L. pseudoconica, Macbrideola cornea, Physarum decipiens, P. flavicomum, P. globuliferum, P. gyrosum, P. mutabile, P. nicaraguense, P. oblatum, P. rigidum, P. roseum, P. stellatum, Reticularia jurana* and *Trichia agaves*. Ten species (*Comatricha anomala, Craterium paraguayense, Cribraria macrocarpa, Didymium bahiense, L. pseudoconica, Macbrideola cornea, Physarum decipiens, P. gyrosum, P. mutabile* and *Trichia agaves*) were new records for the insular Caribbean. Species little studied by SEM or of particular interest for the island's biota are illustrated with SEM micrographs of spore ornamentation prepared by critical point drying.

Key words — biodiversity, *Myxomycota*, Neotropical myxobiota

Introduction

The recent increase in biodiversity studies of myxomycetes from the tropics and subtropics has taken place primarily in Central and South American countries such as Costa Rica (Schnittler & Stephenson 2000), Ecuador (Schnittler & Stephenson 2002, Stephenson et al. 2004) and Mexico (Lizárraga et al. 1997, 1998, 1999a,b, 2003, 2005a,b; Lado et al. 1999, 2003; Moreno et al. 2006, Stephenson et al. 2003). For the insular Caribbean there has been some exploration of Puerto Rico (Novozhilov et al. 2001), although the most important recent study of myxomycete biogeography for the region is a general compilation of fungi which also includes myxomycetes (Minter et al. 2001, 2002).

There are still, however, very few works relating to this group of organisms from the Caribbean, despite an ample variety of ecosystems with a great diversity of conditions and suitable substrates for their development. The present study, using field collections and specimens obtained from moist chamber cultures, was carried out because there is still very little published information about myxomycetes in Cuba, the largest island of the region. Some species already recorded from Cuba are also included where there are new locality records.

Materials and methods

Voucher material used in this study has been deposited in the myxomycete reference collection of the Jardín Botánico Nacional, Habana (HAJB) and/or in some cases the reference collection in Alcalá de Henares (AH), and are from collections carried out in different areas of the country. Specimens of myxomycetes fruiting under natural conditions in the field were reviewed. The moist chamber culture technique (Stephenson & Stempen, 1994) was used to reveal species associated with certain microhabitats, especially the bark surfaces of living trees.

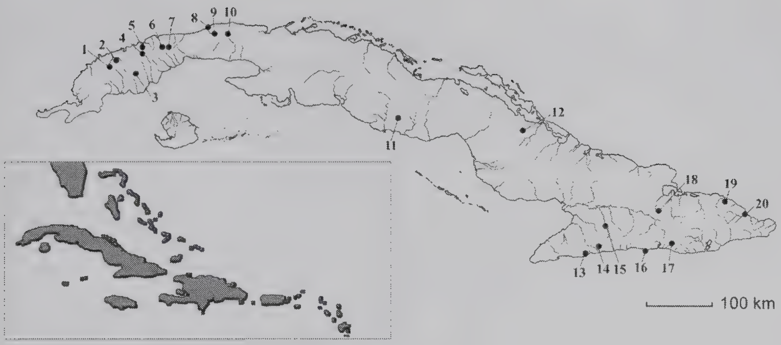
Samples for light microscopy were mounted in Hoyer's medium or PVA following Schnittler & Novozhilov (1996) and Koske & Tessier (1983). Spore measurements were made using an oil immersion objective and include such surface structures as spines or warts.

Scanning electron microscopy (SEM) images were prepared using critical point drying (Castillo et al. 1997); the photomicrographs were produced at the University of Alcalá using a Zeiss DSM–950. This technique allows the use of very little material (part of single sporocarp or even no more than a few spores).

The terminology used for the spore-producing stages follows Dörfelt & Marx (1990) and Lado & Pando (1997). Spore wall ornamentation as seen by SEM is described according to the terminology proposed by Rammeloo (1975a,b) and abbreviations for author citations follow Kirk & Ansell (1992). The nomenclature used follows Lado (2001) and Lado et al. (2005).

Species in the annotated list below are arranged alphabetically and new records for Cuba are preceded by an asterisk. Records based on specimens harvested from moist chamber cultures are indicated in each instance by "bc". Numbers relating to material supplied by David Mitchell are indicated by "DWM".

The material considered in this study came from 58 localities. These localities are listed under provinces and municipalities in order from west to east, with an identifying number assigned to each (Map, Table 1).



Map 1. Localities of the material studied.

Table 1. Province, municipality, locality and species name of the material studied.

Province	Municipality	Locality
1–7. Pinar del Río	1. Viñales	1.1. km 17, Viñales–Pons highway, to the right of the bridge over the La Caoba river
		1.2. Parque Nacional Viñales, highway to Moncada, ecotourist path "Maravillas de Viñales"
	2. Viñales	2.1. Parque Nacional Viñales, haystack hills ("mogotes") of the Mural de la Prehistoria, hill path
	3. Consolación del Sur	3.1. Cruz de Joaquin
	4. La Palma	4. 1. Area Protegida de Recursos Manejados "Mil Cumbres", near the biological station
		4.2. Area Protegida de Recursos Manejados "Mil Cumbres", Reserva San Marcos
		4.3. Area Protegida de Recursos Manejados "Mil Cumbres", between the forest keeper's house & Lagunita
		4.4. El Badén, banks of the Buren river, on the El Caimito path
	5. La Palma	5.1. Area Protegida de Recursos Manejados "Mil Cumbres", Pan de Guajaibón
	6. Candelaria	6.1. Los Tumbos
	7. Candelaria	7.1. Reserva de la Biosfera "Sierra del Rosario, El Salón, near the Academy house
8–9. Ciudad de la Habana	8.1. Arroyo Naranjo	8.1.1. Near the bridge of Calle 100 and Bejucal street
	8.2. Boyeros	8.2.1. Jardín Botánico Nacional, greenhouse of succulent plants, 100 msm
		8.2.2. Jardín Botánico Nacional, Jardín Japonés, 100 msm
		8.2.3. Jardín Botánico Nacional, "El Bambú", near the restaurant, 100 msm
		8.2.4. Jardín Botánico Nacional, Panch Simón stream, 100 msm
		8.2.5. Jardín Botánico Nacional, El Pinar, 100 msm
		8.2.6. Jardín Botánico Nacional, Cuba Zone, 100 msm
		8.2.7. Jardín Botánico Nacional, 100 msm
		8.2.8. Jardín Botánico Nacional, chalet, 100 msm
	9. Plaza de la Revolución	9.1. Facultad de Biología, yard

Table 1, *continued*

10. La Habana	10. Jaruco	10.1. Approximately 2.3 km from the restaurant "El Arabe"
11. Sancti Spíritus	11. Sancti Spíritus	11.1. Reserva Ecológica "Alturas de Banao", junction of the Banao river, Mª Antonia's farm
		11.2. Reserva Ecológica "Alturas de Banao", junction of the Higuanojo river, the north of La Sabina biological station, after the pine grove
		11.3. Reserva Ecológica "Alturas de Banao", La Sabina biological station
		11.4. Reserva Ecológica "Alturas de Banao", Caja de Agua, tunnel stream
		11.5. Reserva Ecológica "Alturas de Banao", Caja de Agua, head of the tunnel stream
		11.6. Reserva Ecológica "Alturas de Banao", head of the Higuanojo river, north of La Sabina biol. stn, 575 msm
		11.7. Reserva Ecológica "Alturas de Banao", Cortinas Blancas, on the way to the waterfall
		11.8. Reserva Ecológica "Alturas de Banao", path to Cortinas Blancas, banks of Higuanojo river
		11.9. Reserva Ecológica "Alturas de Banao", La Sabina, junction of the Banao river
		11.10. Reserva Ecológica "Alturas de Banao", La Sabina, border of field station area
		11.11. Reserva Ecológica "Alturas de Banao", near the La Sabina biological station, 620 msm
		11.12. Reserva Ecológica "Alturas de Banao", Las Damas, Vladimir's farm
		11.13. Reserva Ecológica "Alturas de Banao", Los Leones stream, upper slopes between La Sabina and the ridge leading to Caja de Agua, 620 msm
		11.14. Reserva Ecológica "Alturas de Banao", on path from Mª Antonia's farm to Ruinas de Boleto
		11.15. Reserva Ecológica "Alturas de Banao", path on the ridge between La Sabina and Caja de Agua
		11.16. Reserva Ecológica "Alturas de Banao", stream at the southwest base of Tetas de Juana, 600 msm
		11.17. Reserva Ecológica "Alturas de Banao", La Sabina stream, junction of the Banao river
		11.18. Reserva Ecológica "Alturas de Banao", Tetas de Juana, southwest hillside, 600 msm
		11.19. Reserva Ecológica "Alturas de Banao", Tetas de Juana.
		11.20. Reserva Ecológica "Alturas de Banao", route from La Sabina biological station to El Regalo, spring area to the north, 500 msm
		11.21. Reserva Ecológica "Alturas de Banao", route from La Sabina biological station to Ruinas de Boleto
		11.22. Reserva Ecológica "Alturas de Banao", route from La Sabina biological station to Hoyo del Naranjal, 2 km from La Sabina biological station, 500 msm
12. Camagüey	12. Sierra de Cubitas	12.1 Hoyo de Bonet
18–19. Holguín	18. Mayarí	18.1. La Mensura hill, base of south slope
	19 Moa	19.1. Cayoguan River, left bank, near the campsite
14–15. Granma	14. Buey Arriba	14.1. Path to Pata de la Mesa, on the left toward the La Mesa River and Fajardo farm
	15. Guisa	15.1. Jardín Botánico Cupaynicú, bank of a river

TABLE 1, *concluded*

13, 16–17. SANTIAGO DE CUBA	13. GUAMÁ	13.1. Parque Nacional Turquino, path between Pico Cuba and Las Cuevas
		13.2. Parque Nacional Turquino, path between Pico Cuba and Paso del Cadete, 1400 msm
		13.3. Parque Nacional Turquino, path from Pico Cuba to Las Cuevas, near Alto del Caldero, 1265 msm
		13.4. Parque Nacional Turquino, Pico Cuba, 1872 msm
		13.5. Parque Nacional Turquino, Pico Regino, 1600 msm
		13.6. Parque Nacional Turquino, path between Aguada de Joaquín and Alto Joaquín
	16. GUAMÁ	16.1. Arroyón River, on the ascent of El Gato hill
	17. SANTIAGO DE CUBA	17.1. La Isabelica
20. GUANTÁNAMO	20. BARACOA	20.1. Path to Yunque de Baracoa

Annotated species list

* ***Calomyxa metallica*** (Berk.) Nieuwl., American Midland Naturalist 4: 335 (1916).

MATERIAL EXAMINED. LOCALITY 8.2.7, moist chamber culture on bark of *Antidesma montanum*, 12–03–2003, *leg.* M. Camino, obtained by D.W. Mitchell, *DWM 6810bc.*

DISTRIBUTION: This is a new record for Cuba. In the insular Caribbean, the species was known previously only from Jamaica (Minter et al. 2001).

* ***Clastoderma debaryanum*** var. ***debaryanum*** A. Blytt, Bot. Zeitung (Berlin) 38: 343 (1880).

MATERIAL EXAMINED. LOCALITY 13.5, on wood debris, 19–XI–2003, *leg.* M. Camino, J.L. Ortiz & J. M. Pérez, *HAJB 9795.*

DISTRIBUTION: Together with samples from the Ecological Reserve "Alturas de Banao" (Camino et al. 2007), this is the first record for Cuba. In the insular Caribbean this variety has been recorded from Dominica, Guadeloupe and Jamaica (Minter et al. 2002).

COMMENTS – The sample is abundant and shows the characteristics of the typical variety, well illustrated in Emoto (1977).

* ***Comatricha anomala*** Rammeloo, Bull. Jard. Bot. Natl. Belg. 46: 237 (1976).

MATERIAL EXAMINED. LOCALITY 8.2.7, moist chamber culture on bark of *Jacaranda arborea*, 12–III–2003, *leg.* M. Camino obtained by D.W. Mitchell, *DWM 6840bc*, HAJB (dried specimens), AH (slide only).

DISTRIBUTION: This is a new record for Cuba and insular Caribbean.

COMMENTS – *Comatricha anomala* differs from other species of the genus in its unique spore ornamentation. This taxon has been reported from several localities in Europe and from California (USA), an unspecified location in North America (Kowalski & Demaree 1987) and Baja California, Mexico (Lizárraga et al. 1997).

* ***Comatricha tenerrima*** (M.A. Curtis) G. Lister, Guide to Brit. Mycetozoa, ed. 4: 39 (1919).

Material examined. Locality 11.9, on rotten trunk of *Samanea saman*, 14–XI–2003, *leg.* M. Camino & J. L. Ortiz, *HAJB 9631.*

Distribution: In the insular Caribbean, this species has been recorded previously from Jamaica (Minter et al. 2002).

Comments – This species is characterized by an ovoid sporotheca, a pale brown colour, a sharp apex to the sporotheca and a sinuous capillitium. This collection, along with another three, also from the Ecological Reserve "Alturas de Banao" (Camino et al. 2007) are the first records from Cuba.

Craterium leucocephalum **var.** ***scyphoides*** (Cooke & Balf. f.) G. Lister, in Lister, Monogr. Mycetozoa, ed. 2: 97 (1911).

Material examined. Locality 11.18, on dry twig, 26–I–1997, *leg.* M. Camino, *HAJB 7632.* Locality 11.11, on dry leaf and twig, 18–09–1997, *leg.* U. Eliasson, M. Camino, E. Bécquer & J. Calviño, *HAJB 7809.* Locality 13.3, on wet leaf, 21–XI–2003, *leg.* M. Camino, J. L. Ortiz & J. M. Pérez, *HAJB 9843.*

Distribution: *C. leucocephalum* s.l. has been recorded from Cuba, Dominica, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – *Craterium leucocephalum* var. *scyphoides* differs from *C. leucocephalum* var. *leucocephalum* (Pers. ex J.F. Gmel.) Ditmar in having smaller sporocarps and globose to subglobose sporothecae, where var. *leucocephalum* has cylindrical or turbinate sporothecae. The spore ornamentation is also more pronounced.

* ***Craterium paraguayense*** (Speg.) G. Lister, in Lister, Monogr. Mycetozoa, ed. 2: 95 (1911). Figs. 1–3

Material examined. Locality 13.3, on leaf and dry twig, 21–XI–2003, *leg.* M. Camino, J.L. Ortiz & J.M. Pérez, *HAJB 9844.*

Distribution: *Craterium paraguayense* was described originally from Paraguay (hence its name), and was considered by Martin & Alexopoulos (1969) "to be largely subtropical or tropical". This is a new record for Cuba and the insular Caribbean.

Comments – This species is characterized by stipitate sporocarps, cylindrical violet sporothecae with apical circumscissile dehiscence, and cylindrical and central pseudocolumellae with large calcium carbonate nodes of more or less intense violet colour.

Castillo et al. (2002) made comparative studies of the types of *Craterium paraguayense* and *Physarum newtonii* T. Macbr., for both macroscopic and microscopic characters. The spore ornamentation, under both OM and SEM show marked differences between the species. In *C. paraguayense* the spores have small warts when viewed with the OM and short and narrow baculae when viewed with the SEM; in *P. newtonii* there are very pronounced warts (OM) and thick, prominent baculae (SEM). These characters were also observed in the Cuban collection.

The Cuban specimen has violet to white-violet tones that look like discoloured forms of *Craterium leucocephalum* var. *scyphoides*, but the black stipe and spore ornamentation under SEM show the typical decoration of warts or short and narrow baculae of *C. paraguayense* (Castillo et al. 2002).

* ***Cribraria confusa*** Nann.-Bremek. & Y. Yamam., Proc. K. Ned. Akad. Wet., Ser. C, Biol. Med. Sci. 86(2): 212 (1983).

Material examined. Locality 13.4, in moist chamber culture on bark of *Cyrilla* sp., *leg.* M. Camino, 20–XI–2003, obtained by D.W. Mitchell 2–03–2006, *DWM 7048bc.*

Distribution: This is a new record for Cuba. In the insular Caribbean it has been recorded previously from Dominica (Minter et al. 2002).

Comments – This species has the following characters: sporocarps small, long-stalked, yellow and 0.3–0.7 mm in height; sporothecae small, globose, 0.05–0.2 mm diam., with a globose to subglobose; evanescent peridium, from which threads originate forming a net of polygonal meshes up to 40 μm diam., with narrow more or less isodiametric threads about 1 μm diam., and slightly flattened nodes with small and sparse mounds of calcium oxalate globules present at the union of the threads; stalk hyaline to straw-yellow, 0.2–0.5 mm long, with granular material from half the height upwards; hypothallus inconspicuous; spores are 5–7 μm diam., globose to subglobose, warted and with small crests, light yellow under OM.

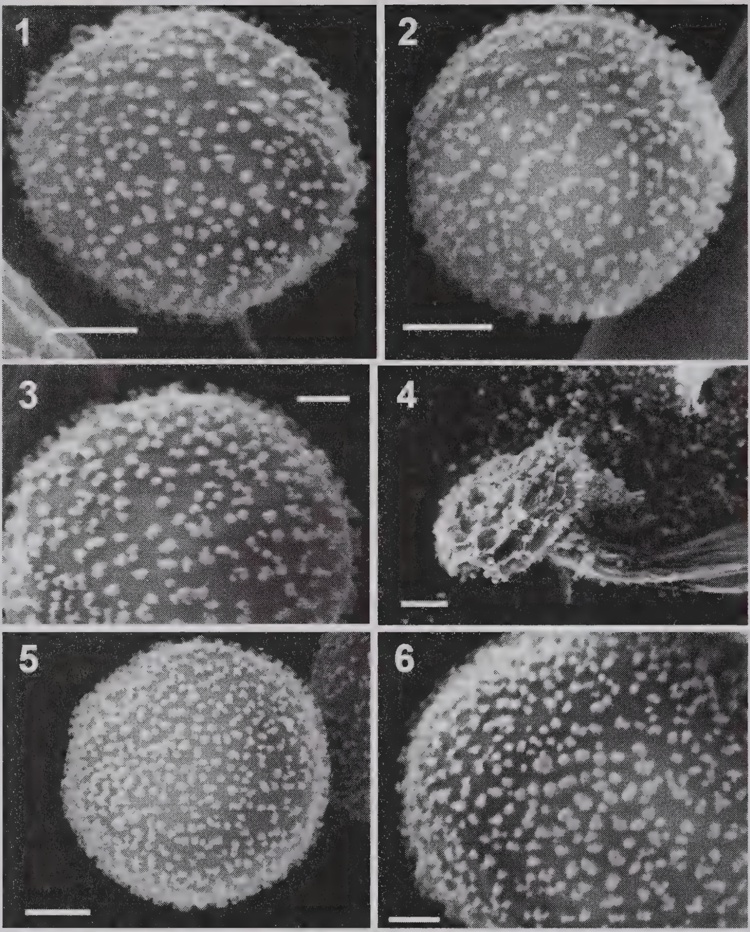
Cribraria confusa was described by Nannenga-Bremekamp & Yamamoto (1983), separating it clearly from *C. minutissima* Schwein. The two species were compared using SEM by Keller et al. (1988). It was reported recently from Chihuahua (México) by Lizárraga et al. (2003).

Cribraria intricata Schrad., Nov. Gen. Pl.: 7 (1797).

Material examined. Locality 12.1, on decayed wood with mosses, 16–05–95, *leg.* M. Camino & R. Rankin, *HAJB 7355*. Locality 7.1, on a very wet dead trunk, 07–X–1999, *leg.* M. Benitez, *HAJB 8568*, DWM 6723bc (slide). Locality 11.6, wet evergreen forest, on decayed twig, 24–XI–2002, *leg.* M. Camino, *HAJB 9415.*

Distribution: This species is listed for Cuba by Farr (1976) from a specimen deposited in FH; this was later confirmed by Camino et al. (2005).In the insular Caribbean, it has been recorded from Cuba, Dominica, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – This species has a long stipe, 4/5 of the total sporocarp height. The sporotheca has a cup with a calyculus with prominent, dark pulvinate nodes filled with dictydine granules, each with radial, smooth and hyaline free ends, 1–1.5 μm diam. Spores are 5–6 μm diam., ochraceous in mass, pallid under OM.



Figs. 1–3 *Craterium paraguayense* HAJB 9844, 1–2. Spores (bar = 2 µm). 3. Detail of spore ornamentation (bar = 1 µm). Figs. 4–6. *Didymium bahiense,* HAJB 9827. 4. Detail of the lenticular columella (bar = 50 µm). 5. Spores (bar = 2 µm). 6. Detail of spore ornamentation (bar = 1 µm).

Cribraria tenella Schrad. is very close to *C. intricata* and is often difficult to differentiate because of the presence of intermediate forms (Farr 1976). It is frequent in North America and was cited from Cuba in 1869. It would be interesting to investigate the possible synonymy of these two species and study American and European collections.

Cribraria languescens Rex and *C. stellifera* Nowotny & H. Neubert are related to *Cribraria intricata*. The first has coppery coloured sporothecae, flat nodes and spores of 6.5–7.5 µm; the second has larger spores of 9–10 µm diam., and is a temperate species.

* ***Cribraria macrocarpa*** Schrad., Nov. Gen. Pl.: 8 (1797).

Material examined. Locality 18.1, on bark of *Pinus cubensis*, 01–07–2004, *leg.* M. Camino, *HAJB 10322*

Distribution: This is a new record for Cuba and the insular Caribbean. For the Neotropics it has been reported previously only from Colombia and the USA (Florida) (Farr 1976).

Comments – This species is characterized by its 0.5–0.8 mm diam. curved to nodding olive-coloured sporothecae, and a 1–2 mm long black stipe. Empty sporothecae have a pronounced transparency, with hollows and lines or smooth approximately fusiform ribs; the upper part of the sporothecae have smooth fusiform nodes, with abundant radial free ends. The 5–6 µm diam. spores are almost smooth and hyaline.

Cribraria microcarpa (Schrad.) Pers., Syn. Meth. Fung.: 190 (1801).

Material examined. Locality 11.16, on bark of rotten trunk, 20–IX–97, *leg.* U. Eliasson, M. Camino, E. Bécquer & J. Calviño, *HAJB 7895.* Locality 1.2, on rotten trunk, 15–XII–2003, *leg.* M. Cabarroi, M. Camino & J. M. Pérez, *HAJB 9917.*

Distribution: Together with the collections of Camino et al. (2007) from the Ecological Reserve "Alturas de Banao", these are the first records from Cuba. In the insular Caribbean, this species has been recorded from Dominica, Guadeloupe, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – This species is characterized by its small size, long and thin stipe, peridial network with dark nodes and a small dark calyculus. This material was gathered in the field from very wet substrata.

* ***Dictydiaethalium plumbeum*** (Schumach.) Rostaf. ex Lister, Monogr. Mycetozoa: 157 (1894).

Material examined. Locality 11.4, on decayed wood, 28–I–2004, *leg.* M. Camino, M. Cabarroi, A. Fidalgo, J.M. Pérez & T. Rojas, *HAJB 10048.* Locality 5.1, under bark of very hard dry trunk, 19–III–2006, *leg.* M. Camino, *HAJB 10863.*

Distribution: These specimens constitute the first records for Cuba. Previously in the insular Caribbean, this species has been recorded from the American Virgin Islands, the Dominican Republic and Puerto Rico (Minter et al. 2002).

Comments – *Dictydiaethalium plumbeum* forms a depressed pseudoaethalium consisting of closely compacted sporocarps. The upper peridium is tesselate. The colour of the fructifications studied was yellowish brown; the other characters were typical for this species.

Diderma effusum (Schwein.) Morgan, J. Cincinnati Soc. Nat. Hist. 16: 155 (1894).
= *D. cubense* Berk. & M.A. Curtis, in Berkeley, *J. Linn. Soc. Bot.* 10: 347 (1868).

Material examined. Locality 13.1, on dry leaf, 20–XI–2003, *leg.* M. Camino J. L. Ortiz & J.M. Pérez, *HAJB 9829. Idem*, *HAJB 9830.* Locality 11.14, on dry leaf, 30–I–2004, *leg.* M. Camino, M. Cabarroi, A. Fidalgo, J.M. Pérez & T. Rojas, *HAJB 10190.*

Distribution: In the insular Caribbean, this species has been recorded from Cuba, Dominica, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – This species is frequent in Cuba. After studying type material of *Diderma cubense*, we agree with Farr (1976) that this name is a synonym of *D. effusum* and not of *D. testaceum*, as Martin & Alexopoulos (1969) had indicated previously (Camino et al. 2005).

* ***Diderma testaceum*** (Schrad.) Pers. Syn. Meth. Fung.: 167 (1801).

Material examined. Locality 11.15, 25–XI–2002, *leg.* M. Camino, *HAJB 9430.*

Distribution: In the insular Caribbean, this species has been recorded from Cuba, Guadeloupe, Jamaica and the Dominican Republic (Minter et al. 2002).

Comments – This species is characterized by sessile sporocarps which are grouped, pulvinate, and whitish in colour. The peridium is double with the outer layer porcelain–like, and the columella is prominent and hemispherical. The spores are 8–10 μm diam., pale brown by transmitted light, and slightly ornamented. The colour of the sporocarps of our samples was almost white, not pinkish as usually described for this species, but other characters were similar.

* ***Didymium bahiense*** Gottsb., Nova Hedwigia 15: 365 (1968). Figs. 4–6

Material examined. Locality 8.2.7, on branches of *Thunbergia grandiflora*, 30–V–90, *leg.* M. Benítez & M. Camino, *HAJB 6657.* Locality 13.1, on leaves and branches, 20–XI–2003, leg. M. Camino, J.L. Ortiz & J.M. Pérez, *HAJB 9827.* Locality 2.1, on dead leaves, 15–XII–2003, *leg.* M. Camino, M. Cabarroi & J.M. Pérez, *HAJB 9900.*

Distribution: These samples are the first records from Cuba and the insular Caribbean.

Comments – The specimens studied fruited on remains of twigs and leaves, and show characteristics typical for this species. These include a white, lenticular to subglobose columella, a transparent peridium covered with crystals of calcium carbonate and spores 9–10 μm diam., with groups of larger and darker warts. This species is has been recorded previously from Brazil, Ecuador and Venezuela (Farr 1976).

Didymium clavus (Alb. & Schwein.) Rabenh., Deutschl. Krypt.-Fl. 1: 280 (1844).

Material examined. Locality 8.2.2, on twigs of *Thunbergia* sp., 22–V–96, *leg.* M. Camino & O. Álvarez, *HAJB 7532.* Locality 20.1, on wet rotten wood, 07–VII–2004, *leg.* M. Camino, *HAJB 10408.*

Distribution: *Didymium clavus* is abundant in the insular Caribbean (Minter et al. 2001).

Comments – This species is easy to distinguish because of the black base of the discoid sporotheca and the dark stipe. The specimens studied had capillitia with dark forked or three–forked tips and spores 6–7 μm diam., with small warts and some groups of larger and darker warts.

* ***Didymium difforme*** (Pers.) Gray, Nat. Arr. Brit. Pl. 1: 571 (1821).

Material examined. Locality 11.9, on leaves, 20–II–00, *leg.* E. Bécquer, J. Calviño, M. Camino, J.M. Pérez, D. Minter & Y. Tykhonenko, *HAJB 8653.*

Distribution: This is the first record from Cuba. In the insular Caribbean, this species has been recorded previously from Dominica, Haiti and Jamaica (Minter et al. 2002).

Comments – The Cuban collection has characteristics typical of this species: sessile and depressed sporocarps and rarely plasmodiocarps, without columellae, a smooth peridium and 8–10 µm diam. dark spores with minute warts.

* ***Didymium nigripes*** (Link) Fr., Syst. Mycol. 3:119 (1829).

Material examined. Locality 14.1, on litter and rotten bark, 13–V–1988, *leg.* M. Camino, *HAJB 5781.* Locality 11.18, on dry leaf, 26–I–97, *HAJB 7637.* Locality 11.9, on leaves, 20–II–00, *leg.* E. Bécquer, J. Calviño, M. Camino, J.M. Pérez, D. Minter & Y. Tykhonenko, *HAJB 8649.* Locality 8.2.7, on soil and twigs of *Delonix regia*, 25–II–2003, *leg.* M. Clavel, *HAJB 9520.* Locality 13.6, on dead leaf of *Psychotria*, 18–XI–2003, *leg.* M. Camino, J.L. Ortiz & J.M. Pérez, *HAJB 9764.* Locality 11.19, on bark of *Samanea saman*, I–2004, *leg.* M. Camino, J.L. Ortíz, *HAJB 9629.*

Distribution: These are the first records from Cuba. In the insular Caribbean, this species has been recorded previously from the American Virgin Islands, Antigua, Dominica, the Dominican Republic, Haiti, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – This species is frequent on twigs and leaf remains. *Didymium nigripes* is close to *D. bahiense* but is easily differentiated by its blackish stipe, areolate peridium and smaller, biconvex and dark columella.

Didymium squamulosum (Alb. & Schwein.) Fr., Symb. Gasteromyc.: 19 (1817).
= *Didymium costatum* Fr., *Syst. Mycol.* 3: 118 (1829).

Material examined. Locality 8.2.4, on stump of tree, 31–I–1991, *leg.* M. Bénitez & D. López, *HAJB 6688.*

Distribution: This cosmopolitan species was noted (as *Didymium costatum*) from Cuba by Berkeley (1869), Massee (1892) and Camino et al. (2007).In the insular Caribbean, it has been recorded from Cuba, Dominica, the island of Hispaniola, Jamaica, Martinique, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

* ***Echinostelium minutum*** de Bary, in Rostafiński, Sluzowce Monogr.: 215 (1874).

Material examined. Locality 4.4, in moist chamber culture on bark of *Pinus* sp., *DWM 7050bc.* Locality 4.4., on *Quercus* sp. in moist chamber culture, *DWM 7051bc.* Locality 11.3, on bark of *Pinus caribaea* moist chamber culture, 25–XI–02, *leg.* S. Stephenson (no specimen) *DWM 6769bc.* Locality 8.2.7, on bark of *Diospyros discolor* in moist chamber culture, 12–III–2003, *leg.* M. Camino *DWM 6807bc.*

Distribution: This is a cosmopolitan corticolous species. Together with specimens from the Ecological Reserve "Alturas de Banao" (Camino et al. 2007), these are the first records for Cuba. In the insular Caribbean, this species has been recorded from Dominica, Guadeloupe, Grenada, Jamaica, and Trinidad & Tobago (Minter et al. 2002).

Hemitrichia calyculata (Speg.) M.L. Farr, Mycologia 66(5): 887 (1974). Figs. 7–9

Material examined. Locality 1.1, on dead humid trunk, 20–VI–2000, *leg.* M. Camino, *HAJB 8733.* Locality 1.2, on dead wood, 16–XII–2003, *leg.* M. Cabarroi, M. Camino & J.M. Pérez, *HAJB 9946.* Locality 11.20, on rotten wood, 27–I–2004, *leg.* M. Camino, M. Cabarroi & J.M. Pérez, *HAJB 9963, HAJB 9976.* Locality 10.1, on rotten, wooden remains, 8–IV–2004, *leg.* G. Arnold, M. Camino, S. Maldonado, J.M. Pérez & G. Recio, *HAJB 10275.* Locality 19.1, on dead trunk, 03–VII–2004, *leg.* M. Camino, *HAJB 10342.*

Distribution: This is one of the most frequent species in Cuba and is mentioned in several earlier works (Berkeley 1869, Massee 1892) and more recently by Farr (1976), Camino (1993, 1998b), Pérez & Camino (2000), Camino & Pérez (2001), and Camino et al. (2005, 2007). In the insular Caribbean, it has been recorded from Cuba, Dominica, the Dominican Republic, Guadeloupe, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – The sample HAJB 10275 has a cylindrical, blackish and very slighty developed stipe about 1 mm long and a capillitium with 6–8 μm diam. elaters with few obtuse free ends. The spores are 7–8 μm diam., subreticulate.

Hemitrichia serpula (Scop.) Rostaf. & Lister, Monogr. Mycetozoa: 179 (1894). Figs. 10–12

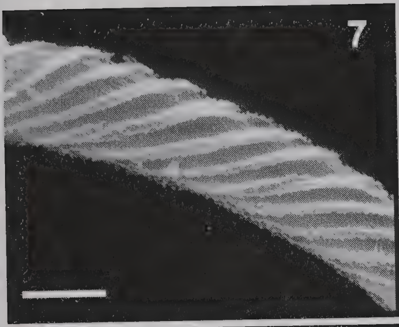
Material examined. Locality 11.9, on rotten petiole of *Roystonea regia*, 20–II–00, *leg.* E. Bécquer, J. Calviño, M. Camino, J.M. Pérez, D. Minter & Y. Tykhonenko, *HAJB 8657.* Locality 11.20, on rotten wood, 27–I–2004, *leg.* M. Camino, M. Cabarroi & J.M. Pérez, *HAJB 9976. Ibidem*, on rotten petiole of *Roystonea regia*, *HAJB 9977.* Locality 11.5, on rotten petiole of *Roystonea regia*, 28–I–2004, *leg.* M. Cabarroi, M. Camino, J.M. Pérez &. T. Rojas, *HAJB 10040.* Locality 11.1, on soil, 29–I–2004, *HAJB 10108.* Locality 11.14, on rotten wood, 28–I–2004, leg. M. Camino, *HAJB 10187.*

Distribution: This is a very frequent species in Cuba. It has been mentioned by Berkeley (1869), Massee (1892), Farr (1976), Camino (1993, 1998b), Pérez & Camino (2000), Camino & Pérez (2001), and Camino et al. (2005, 2007). In the insular Caribbean, it has been recorded from Cuba, Dominica, the Dominican Republic, Guadeloupe, Jamaica, Puerto Rico, Saint Lucía and Trinidad & Tobago (Minter et al. 2002).

Lamproderma arcyrionema Rostaf., Sluzowce Monogr.: 208 (1874).

Material examined. Locality 11.7, on dead trunk, 20–III–1999, *leg.* M. Camino, D. Minter & J.M. Pérez, *HAJB 8439.* Locality 11.21, on decayed wood, 19–VIII–2003, *leg.* M. Camino, *HAJB 9600.* Locality 11.9, on rotten wood of *Samanea saman*, 14–XI–2003, *leg.* M. Camino & J.L Ortiz, *HAJB 9639.* Locality 13.3, on wooden remains, 21–XI–2003, *leg.* M. Camino, J.L. Ortiz & J.M. Pérez, *HAJB 9846.* Locality 20.1, on dead trunk, 07–VII–2004, *leg.* M. Camino, *HAJB 10406.*

Figs. 7–9 *Hemitrichia calyculata* HAJB 9946. 7. Capillitium (bar = 5 μm). 8. Spore (bar = 2 μm). 9. Detail of spore ornamentation (bar = 1 μm). Figs. 10–12 *Hemitrichia serpula* HAJB 9977. 10. Capillitium (bar = 5 μm). 11. Spore (bar = 2 μm). 12. Detail of spore ornamentation HAJB 10187 (bar = 1 μm). Figs. 13–14. *Stemonitis axifera* HAJB 9916. 13. Spore (bar = 1 μm). 14. Detail of spore ornamentation (bar = 1 μm).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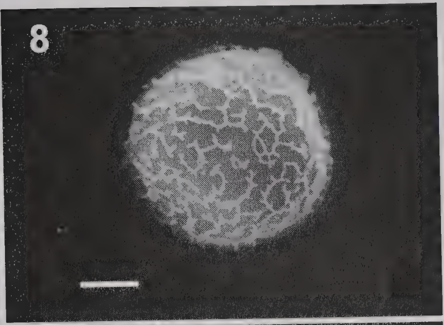
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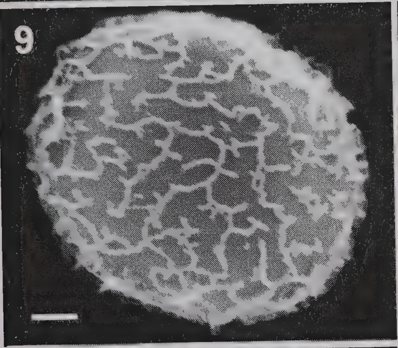
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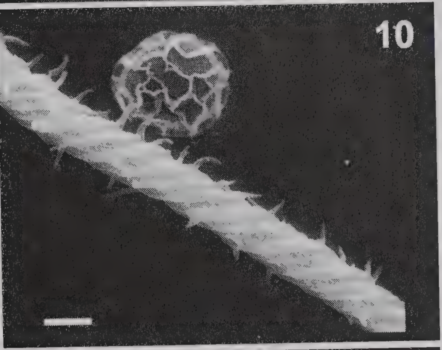
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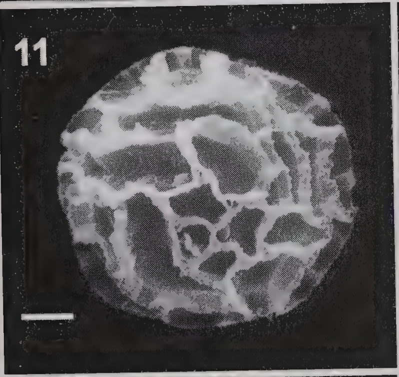
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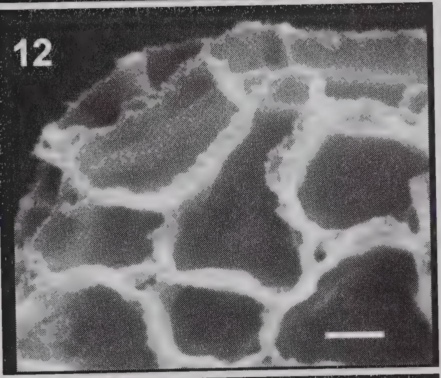
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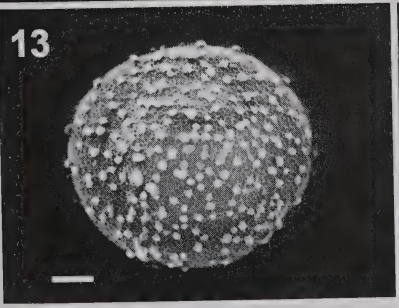
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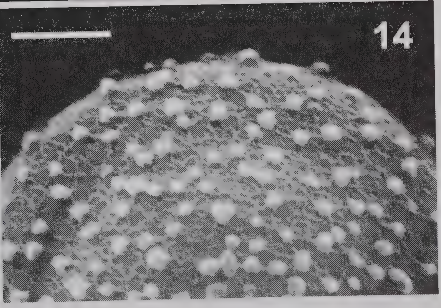
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Distribution: It is frequently found in Cuba on ligneous remains. The species was cited recently by Càmino & Pérez (2001) and Camino et al. (2007). In the insular Caribbean, it has been recorded from Cuba, Dominica, the island of Hispaniola (the Dominican Republic and Haiti), Jamaica, Puerto Rico and Saint Lucía (Minter et al. 2002).

Comments – This species is well characterized by globose sporothecae, a silvery to bronze peridium, a columella tapering towards the centre of the sporotheca and a capillitium with main branches and sinuous filaments. The spores are (6–) 7–9 µm diam., with groups of darker warts.

Licea biforis Morgan, J. Cincinnati Soc. Nat. Hist. 15: 131 (1893).

Material examined. Locality 8.2.8, on litter of *Thunbergia grandiflora*, 14–X–1992, *leg.* W. Alonso & M. Camino, *HAJB 7050. Ibidem*, on bark of *Pouteria mammosa* in moist chamber culture, 12–III–2003, *leg.* M. Camino, obtained by D.W. Mitchell, *DWM 6830bc.* Locality 4.2, on bark, 25–II–1997, *leg.* C. Panfet, *HAJB 7673.*

Distribution: Samples HAJB 7050 and 7673 were mentioned by Minter et al. (2001). In the insular Caribbean, this species has been recorded from Cuba and Jamaica (Minter et al. 2002).

Comments – This species is characterized by its elongated to sinuous, laterally flattened plasmodiocarps. The colour is very variable, ranging from white to fuscous depending on the material incorporated from the substratum. Dehiscence is by a pale longitudinal slit. It is found on bark and litter and, because of its small size, usually observed when studying other samples by OM.

* ***Licea pedicellata*** (H.C. Gilbert) H.C. Gilbert, in Martin, Mycologia 34(6): 702 (1942).

Material examined. Locality 8.2.7, in moist chamber culture on bark of *Terminalia eriostachya*, 12–III–2003, leg. M. Camino, obtained by D.W. Mitchell, *DWM 6842bc.*

Distribution: This is a new record from Cuba. In the insular Caribbean, this species has been recorded from Grenada and Puerto Rico (Minter et al. 2002).

Comments – This corticolous species is distinguished by its stout furrowed stalk and is the only common stipitate *Licea* that dehisces by peridial platelets. The spores have a paler region and appear smooth or minutely spinulose by transmitted light.

* ***Licea pseudoconica*** T.E. Brooks & H.W. Keller, in Keller & Brooks, Mycologia 69(4): 678 (1977).

Material examined. Locality 8.2.7, in moist chamber culture on bark of *Antidesma montanum*, 12–III–2003, leg. M. Camino, obtained by D.W. Mitchell, *DWM 6821bc.*

Distribution: This is a new record from Cuba and the insular Caribbean.

Comments – A corticolous species that, at first sight, resembles a small pyrenomycete because its sessile sporocarps have a conical apical deposit of refuse material. Dehiscence is by rupture of the lateral wall, after which the basal part persists as a shallow cup. The spore–mass is dark brown to almost black. The spores are 9.5–11 (–13) µm diam., olivaceous brown, globose, smooth and with a thin, pale germination pore.

Lycogala epidendrum (L.) Fr., Syst. Mycol. 3: 80 (1829).

Material examined. Locality 8.2.3, on wood of *Pinus* sp., 11–VI–2001, *leg.* M. Clavel, *HAJB 8819.* Locality 11.20, on decayed wood, 27–I–2004, *leg.* M. Camino, M. Cabarroi & J.M. Pérez, *HAJB 9975*; Locality 11.4, on decayed wood, 28–I–2004, *leg.* M. Camino, M. Cabarroi, J.M. Pérez & T. Rojas, *HAJB 10036*; Locality 11.1, on rotten petiole of *Roystonea regia*, 28–I–2004, *leg.* M. Camino, M. Cabarroi, A. Fidalgo, J.M. Pérez & T. Rojas, *HAJB 10106.*

Distribution: This species is very frequent in Cuba and other Caribbean countries. It was one of the first six myxomycetes recorded from the island (Montagne 1845). It has been cited in early (Berkeley 1869, Massee 1892) and more recent works (Farr 1976, Camino 1998b, Camino & Pérez 2001, Camino et al. 2005, Perez & Camino 2000). In the insular Caribbean, it has been recorded from Cuba, Dominica, the Dominican Republic, Guadeloupe, Grenada, Jamaica, Puerto Rico, Saint Lucía and Trinidad & Tobago (Minter et al. 2002).

* ***Macbrideola cornea*** (G. Lister & Cran) Alexop., Mycologia 59(1): 112 (1967).

Material examined. Locality 8.2.7, on bark of *Antidesma montanum* bark in moist chamber culture, 12–III–2003, *leg.* M. Camino, *DWM 6820bc* (slide only),

Distribution: This is a new record from Cuba and the insular Caribbean.

Comments – This is a corticolous species usually found on bryophytes. The distinctly hollow stalk is red to yellow at the base and tapers upwards and extends into about the centre of the sporotheca to form the columella. The spherical sporothecae are mostly 0.1–0.3 mm diam. The peridium is partly persistent as a collar around the stalk apex. The capillitium is dark brown, branched dichotomously, usually only 1–3 times, tapered outwards but remaining fairly stout at the periphery. The spore–mass is dark brown while the spores are lilac–brown or grey–brown, verrucose, and 8–9 µm diam.

Perichaena chrysosperma (Curr.) Lister, Monogr. Mycetozoa: 196 (1894).

Material examined. Locality 11.1, on decayed wood, 28–I–2004, *leg.* M. Camino, M. Cabarroi, A. Fidalgo, J.M. Pérez & T. Rojas, *HAJB 10110.* Locality 10.1, on rotten wood, 08–IV–2004, *leg.* G. Arnold, M. Camino, S. Maldonado, J.M. Pérez & G. Recio, *HAJB 10276.*

Distribution: The species has been cited for Cuba in several works (Berkeley 1869, Massee 1892, Farr 1976, Camino, 1993, 1998b, Camino & Perez 2001, Camino et al. 2005, 2007), and is widely distributed in the insular Caribbean, having been recorded from Cuba, Dominica, the Dominican Republic, Granada, Guadeloupe, Jamaica, Puerto Rico, Saint Lucía and Trinidad & Tobago (Minter et al. 2002).

Comments – This material exhibits characteristics typical of the species: short, elongated or reniform plasmodiocarps, threads of the capillitium with scarce and prominent spines up to 4 μm long and spores 9–11 μm diam.

* ***Physarum decipiens*** M. A. Curtis, Amer. J. Sci. Arts 6: 352 (1848).

Material examined. Locality 8.2.2, 100 msm, on twigs of *Thunbergia* sp., 22–V–1996, *leg.* M. Camino & O. Alvarez, *HAJB 7531* and *HAJB 7532.*

Distribution: This species was not cited for the insular Caribbean by Minter et al. (2001, 2002) and Farr (1976) mentioned it for the Neotropics from Bolivia and, doubtfully, Costa Rica. This is therefore a new record from Cuba and the insular Caribbean.

Comments – *Physarum decipiens* is a species very close to *P. auriscalpium* Cooke and *P. serpula* Morgan in form. According to Farr (1961), they differ in habit of development and structure of the peridial calcium carbonate. *Physarum decipiens* has sessile sporocarps, or short plasmodiocarps, with a typical "badhamioid" capillitium formed by pronounced, yellowish nodes of calcium carbonate. A good photograph of this species can be seen in Neubert et al. (1995).

* ***Physarum flavicomum*** Berk., London J. Bot. 4: 66 (1845).

Material examined. Locality 11.16, on bark of rotten trunk, 20–IX–1997, *leg.* U. Eliasson, M. Camino, E. Bécquer, & J. Calviño, *HAJB 7894.*

Distribution: This species appears to be uncommon in the insular Caribbean and was cited only from Antigua and Trinidad & Tobago by Minter et al. (2001, 2002). This collection is the first record of this species from Cuba.

Comments – This species is characterized by the following features: stipitate sporocarps; usually globose, nodding sporothecae, 0.3–0.4 mm diam.; very delicate, generally iridescent peridia, with whitish to yellowish deposits of calcium carbonate; stalks up to 2 mm long, thin, yellowish to paler towards the apex, dark reddish towards the base; capillitia with white to yellowish nodes. The spores are brown to pale purple, 8–10 μm diam, densely warted, with groups of more prominent warts.

* ***Physarum globuliferum*** (Bull.) Pers., Syn. Meth. Fung.: 175 (1801).

Material examined. Locality 11.22, on wooden remains of *Samanea saman,* 20–XI–2001, *leg.* E. Bécquer, M. Camino, D. Minter & J.M. Pérez, *HAJB 8948a.* Locality 4.1, on rotten palm petiole, 09–XI–2002, leg. M. Camino & J.L. Ortiz, *HAJB 9222.*

Distribution: This collection represents the first record from Cuba but, in the insular Caribbean, this species has been recorded previously from Guadeloupe, Jamaica and Trinidad & Tobago (Minter et al. 2001, 2002).

Comments – This species is characterized by its whitish stalked fructifications, globose sporothecae and whitish peridium. The stalk is calcareous, fragile, narrower towards the apex, and more than four times as long as the diameter of the sporotheca. The capillitium is hyaline with small whitish nodes. The spores are subglobose, 7–10 µm diam., verruculose with more prominent groups of warts.

* ***Physarum gyrosum*** Rostaf., Sluzowce Monogr.: 111 (1874).

Material examined. Locality 8.2.1, on leaves, I–2004, *leg.* M. Cabarroi, *HAJB 9952.*

Distribution: This is a new record from Cuba and the insular Caribbean.

Comments – This species is characterized by its crowded and sinuous aethalial fructifications. The straw–coloured stipe is a continuation of the hypothallus. The peridium is thin, membranous, whitish to cream to straw–coloured. The elastic capillitium is dense with abundant very elongated and whitish fusiform nodes. The spores are 7–10 µm diam., with spinulose ornamentation.

* ***Physarum mutabile*** (Rostaf.) G.Lister, in Lister, Monogr. Mycetozoa, ed. 2: 53 (1911).

Material examined. Locality 11.4, on rotten bark of *Jatropha curcas*, 28–I–2004, *leg.* M. Camino, M. Cabarroi, A. Fidalgo, J.M. Pérez & T. Rojas, *HAJB 10038.*

Distribution: *Physarum mutabile* appears to be rare in the Neotropics (Farr 1976), and this is a new record from Cuba and the insular Caribbean.

Comments – The Cuban material has subglobose, crowded, white to beige sporocarps with a thick peridium and a reticulated capillitium with scanty, small and whitish nodes. At 10–12 µm diam., the spores are larger than those (8–10 µm), cited by Martin & Alexopoulos (1969).

* ***Physarum nicaraguense*** T. Macbr., Bull. Iowa Univ. Lab. Nat. Hist. 2: 382 (1893).

Material examined. Locality 8.1.1, on trunk of *Erythrina grisebachii*, 12–XII–1994, *leg.* M. Clavel, *HAJB 7312.*

Distribution: This collection represents the first record for Cuba, but this species has been recorded previously in the insular Caribbean from Haiti, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2001, 2002).

Comments – The Cuban sample has abundant, crowded fructifications, with subglobose to sinuous whitish sporothecae covered by calcium carbonate, a short, blackish stipe and a blackish hypothallus. The capillitium is dense with whitish broad and angular nodes that join in the centre forming a typical whitish, squashed pseudocolumella. The spores are 9–11 µm diam., dark purplish and warted.

Physarum nucleatum Rex, Proc. Acad. Nat. Sci. Philadelphia 43: 389 (1891).

Material examined. Locality. 11.13, on bark, 19–IX–1997, *leg.* U. Eliasson, M. Camino, E. Bécquer & J. Calviño, *HAJB 7843* and *HAJB 7844.*

Distribution: This species was cited from Cuba for the first time by Minter et al. (2001) and there are two new collections. In the insular Caribbean it has also been recorded from Dominica, Jamaica, Puerto Rico, and Trinidad & Tobago (Minter et al. 2002).

Comments – This species has stipitate sporocarps with whitish globose, fragile sporothecae, 0.5–0.9 mm diam. The stipe is long, 2–3 times the diameter of the sporotheca, straw–yellow, without dark granulations, flattened and expanded towards the base. The reticulate capillitium has small whitish nodes that sometimes join in the centre as a globose whitish pseudocolumella (HAJB 7843). The spores are 6–7.5 µm diam., pale purplish by OM, and warted with slightly darker areas.

* ***Physarum oblatum*** T. Macbr., Bull. Iowa Univ. Lab. Nat. Hist. 2: 384 (1893).

Material examined. Locality 2.1, on rattan of *Cissus sicyoides*, 15–XII–2003, *leg.* M. Cabarroi, M. Camino & J.M. Pérez, *HAJB 9898*.

Distribution: This is a new record from Cuba. In the insular Caribbean, this species has been recorded from Dominica and Jamaica (Minter et al. 2001, 2002).

Comments – This species is distinguished by its stipitate sporocarps with 0.4–0.7 mm diam. lenticular to subglobular sporothecae. It has a thick, but very fragile, peridium, covered with crystals of calcium carbonate that give it a very warted appearance. It is orange yellow in colour. The stalk is of similar length to the diameter of the sporotheca, rigid, and from reddish brown to blackish red. The capillitium is reticulate with abundant yellowish to orange polyhedric, calcareous to fusiform nodes. The spores are globose, 12–13 µm diam., minutely warted and with groups of darker warts.

Physarum pusillum (Berk. & M. A. Curtis) G. Lister, in Lister, Monogr. Mycetozoa, ed. 2: 64 (1919).

Material examined. Locality 15.1, on dry leaf, 01–XII–1994, *leg.* M. Bénitez, *HAJB 7270*.

Distribution: It has been cited previously from Cuba by Camino & Pérez (2001) and Camino et al. (2007). In the insular Caribbean, it has also been recorded from Dominica, the island of Hispaniola (the Dominican Republic and Haiti), Jamaica, and Puerto Rico (Minter et al. 2002).

Comments – *Physarum pusillum* is characterized by its whitish and lenticular sporothecae with irregular dehiscence and blackish stipes.

* ***Physarum rigidum*** (G. Lister) G. Lister, in Lister, Monogr. Mycetozoa, ed. 3: 36 (1925).

Material examined. Locality 6.1, on woody remains, 19–VIII–1987, *leg.* S. Maldonado, R. Rankin & H.D. Gómez, *HAJB 5434*. Locality 9.1, on decayed wood, VIII–1993, *leg.* H. Notario, *HAJB 7108*.

Distribution: This is a new record from Cuba. In the insular Caribbean, this species has been recorded from the American Virgin Island, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2001, 2002).

Comments – This species is characterized by its stipitate sporocarps with very fragile white lenticular sporothecae, approximately 0.7–1 × 0.3–0.4 mm. The stipe is 1.8–2.2 mm long, straw yellow, more orange to orange brown in the lower part, tapered towards the apex, and without lime or granular material. The capillitium has a "badhamioid" structure, formed by parallel yellowish threads from the apex to the base of the sporotheca, with yellowish fusiform elongated nodes. The spores are 8–10 µm diam. and warted.

* ***Physarum roseum*** Berk. & Broome, J. Linn. Soc., Bot. 14 (2): 84 (1873).

Material examined. Locality 3.1, on trunk of *Syzygium jambos*, 5–XII–2001, *leg.* M. Camino & J.M. Pérez *HAJB 9013*.

Distribution: This is a new record for Cuba. In the insular Caribbean this species was previously recorded from Dominica and Jamaica (Minter et al. 2002).

Comments – *Physarum roseum* is characterized by its stipitate and grouped, globose sporocarps, fragile sporothecae, pink to red purple or red scarlet, 0.5–0.6 mm diam., and with irregular to petaloid dehiscence. The stalk is dark brown, 1–1.2 mm long, without calcium carbonate. The capillitium is formed by a net of filaments with large angular reddish to purple nodes, according to drawings by Lister (1925) and Emoto (1977).

* ***Physarum stellatum*** (Massee) G.W. Martin, Mycologia 39(4): 461 (1947).

Material examined. Locality 4.3, on rotten wood, 12–XI–2004, *leg.* M. Camino, M. Cabarroi, L. Castillo, J.M. Pérez, K. Salas, *HAJB 10552*. Locality 11.10, on bark of rotten trunk, 27–I–1997, *leg.* M. Camino, *HAJB 7643*; Locality 11.2, on rotten stalk of *Piper auritum*, 21–IX–1997, *leg.* U. Eliasson, M. Camino, E. Bécquer & J. Calviño, *HAJB 7913*; Locality 11.17, on rotten rachis of *Roystonea regia*, 14–XI–2003, *leg.* M. Camino & J.L. Ortíz, *HAJB 9635*. Locality 1.2, in trunk, 13–I–2002, *leg.* J.M. Pérez & M. Rodríguez., *HAJB 9121*. Locality 11.22, on wooden remains of *Samanea saman*, 20–XI–2001, *leg.* E. Bécquer, M. Camino, D.W. Minter & J.M. Pérez, *HAJB 8948b*.

Distribution: This is a new record from Cuba. In the insular Caribbean this species has been recorded from Dominica, Guadeloupe, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – This species is characterized by the following features: a calcareous stipe, and a peridium with thick patches or scales of calcium carbonate and floriform dehiscence into typical elongated lobes; a globose, white pseudocolumella in the centre of the sporotheca; a capillitium with few, whitish and rounded nodes; globose spores, 8.5–9.5 µm diam., pale purplish, minutely spinose or warted, with warts distributed homogeneously.

Excellent colour illustrations of this species can be found in the books by Emoto (1977) and Lister (1925) and, more recently, in the photographs of Neubert et al. (1995).

Physarum viride (Bull.) Pers., Ann. Bot. (Usteri) 15: 6 (1795).

Material examined. Locality 16.1, in trunk, 01–05–1989, *leg.* M. Benítez & H.D. Gómez, *HAJB 6291*. Locality 13.3, on trunk, 21–XI–2003, *leg.* M. Camino, J.L. Ortiz & J.M. Pérez, *HAJB 9836*.

Distribution: This species has been recorded from Cuba by Camino & Pérez (2001) (Sancti Spíritus) and Camino et al. (2007). In the insular Caribbean, it has also been recorded from Dominica, Guadeloupe, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – *Physarum viride* is characterized by its lenticular and usually nodding sporothecae, a greenish to orange peridium that breaks into petaloid lobes, and a dark stalk, paler at the apex. It has a hyaline, reticulate capillitium with yellowish calcareous nodes. The spores are 7–8 µm diam., globose to subglobose, warted, with groups of darker warts.

* ***Reticularia jurana*** Meyl., Bull. Soc. Vaud. Sci. Nat. 44: 297 (1908).

Material examined. Locality 4.3, on rotten wood, 12–XI–2004, *leg.* M. Camino, M. Cabarroi, L. Castillo, J.M. Pérez, K. Salas, *HAJB 10552*.

Distribution: This collection represents the first record from Cuba and the insular Caribbean.

Comments – This species forms a pulvinate brownish aethalium, and a capillitium with filaments that form an isodiametric reticulum, where its threads turn out to be perforated. The spores are 6–8 µm diam., and reticulated over more or less than half of the surface of spore.

Stemonitis axifera (Bull.) T. Macbr., N. Amer. Slime-Moulds: 120 (1899). Figs. 13–14

Material examined. Locality 11.17, on bark of *Samanea saman*, 29–I–1997, *leg.* M. Camino, *HAJB 9629*. Locality 11.6, on rotten wood of *Guarea guara*, 24–XI–2002, *leg.* M. Camino, *HAJB 9410*. Locality 1.2, on rotten trunk, 15–XII–2003, *leg.* M. Cabarroi, M. Camino & J.M. Pérez, *HAJB 9916*. Locality 8.2.5, on trunk of *Pinus* sp., 22–X–2004, *leg.* M. Camino, *HAJB 10475*.

Distribution: This species is frequent in Cuba and was cited by Camino (1998a) and Camino et al. (2003). In the insular Caribbean it also has been recorded from Dominica, Guadeloupe, the island of Hispaniola (the Dominican Republic and Haiti), Jamaica, Martinique and Trinidad & Tobago (Minter et al. 2002).

Comments – This species is frequent in Cuba. It is characterized by its small spores 5–7 µm diam., smooth by transmitted light, but with a lax and irregular ornamentation formed by baculae and a very thin net observable by SEM.

Stemonitis fusca Roth, Bot. Mag. (Römer & Usteri) 1(2): 26 (1787).

Material examined. Locality 11.19, on bark of *Tabebuia* sp., 14–XI–2003, *leg.* M. Camino & J.L. Ortiz, *HAJB 9637*; Locality 11.20, on trunk of *Tradescantia* sp., 27–I–2004, *leg.* M. Camino, M. Cabarroi & J.M. Pérez, *HAJB 9965a* and *HAJB 9965b*; Locality 11.1, on rotten trunk of *Cecropia schreberiana*, 28–I–2004, *leg.* M. Camino, M. Cabarroi,

A. Fidalgo, J.M. Pérez & T. Rojas, *HAJB 10109*. Locality 13.3, on trunk, 21–XI–2003, *leg*. M. Camino, J.L. Ortiz & J.M. Pérez, *HAJB 9839*. Locality 1.2, rotten trunk, 16–XII–2003, *leg*. M. Cabarroi, M. Camino & J.M. Pérez *HAJB 9922*. Locality 10.1, on petiole of *Roystonea regia*, 08–IV–2004, *leg*. G. Arnold, M. Camino, S. Maldonado, J.M. Pérez & G. Recio, *HAJB 10278*.

Distribution: This species is one of the most frequent of the genus *Stemonitis* in Cuba. It was cited by Berkeley (1869), Massee (1892), Farr (1976), Camino (1998a), Camino & Pérez (2001), and Camino et al. (2003, 2005). In the insular Caribbean it has been recorded from Cuba, Dominica, the Dominican Republic, Guadeloupe, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Stemonitis herbatica Peck, Annual Rep. New York State Mus. 26: 75 (1874).

Material examined. Locality 18.1, on trunk of *Pinus cubensis*, 1–VII–2004, *leg*. M. Camino, *HAJB 10324*; *Ibidem*, on bark of trunk of *Pinus cubensis*, *HAJB 10325*.

Distribution: This species was cited from Cuba by Camino (1998a) and Camino et al. (2003). In the insular Caribbean it has also been recorded from Dominica, the Dominican Republic, Guadeloupe, Jamaica, Martinique and Puerto Rico (Minter et al. 2002).

Comments – Both collections have sporocarps up to 1 mm long and a short stalk (1/5 the total height). The capillitium is formed by perpendicular branches as shown by Nannenga-Bremekamp (1974) and Ing (1999), with small and thin meshes, 3–25 µm diam., and small spines. The spores are globose, 7–9 µm diam., purplish and with regularly distributed minute warts. Although this species typically occurs on herbaceous substrata (leaves, stems and debris), lignicolous records are also known (Martin & Alexopoulos 1969, Camino 1998a).

Stemonitis splendens Rostaf., Sluzowce Monogr.: 195 (1874).

Material examined. Locality 11.21, on leaf of *Guarea guidonia*, 15–XI–2003, *leg*. M. Camino & J.L. Ortiz, *HAJB 9711*; Locality 11.12, on bark of *Cordia* sp., 8–VIII–2004, *leg*. M. Camino, *HAJB 10694*. Locality 13.3, on trunk, 21–XI–2003, *leg*. M. Camino, J.L. Ortiz & J.M. Pérez, *HAJB 9838*. Locality 8.2.6, on trunk of *Hibiscus elatus* and leaves of *Poaceae*, 21–XII–2003, *leg*. M. Clavel, *HAJB 9951*.

Distribution: This species is abundant and was cited from Cuba by Lister (1894, 1925), Macbride & Martin (1934), Martin (1949), Farr (1976), Camino (1998a, 1998b), Pérez & Camino (2000), Camino & Pérez (2001), and Camino et al. (2003, 2005). In the insular Caribbean it has been recorded from Cuba, Dominica, Guadeloupe, Jamaica, Martinique, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Stemonitopsis typhina (F.H. Wigg.) Nann.-Bremek., Nederlandse Myxomyceten: 209 (1975) ["1974"]. Figs. 15–16

= *Stemonitis typhoides* (Bull.) DC., Fl. Franç. 2: 257 (1805).

Material examined. Locality 11.14, on rotten trunk of *Cinnamomum* sp., 30–I–2004, *leg*. M. Camino, M. Cabarroi, A. Fidalgo, J.M. Pérez & T. Rojas, *HAJB 10192*. Locality 19.1, on trunk, 3–VII–2004, *leg*. M. Camino, *HAJB 10349*, *HAJB 10352* and *HAJB 10353*.

Distribution: *Stemonitopsis typhina* has been cited from Cuba by Montagne (1845), Berkeley (1869), Massee (1892), Farr (1976), Camino (1998a), Camino & Pérez (2001) and Camino et al. (2003). In the insular Caribbean, this species has been recorded from Cuba, Dominica, the Dominican Republic, Guadeloupe, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

Comments – This species is characterized by its sporocarps, which have a silver peridium and membranous, silvery remains on the stalk. Some Cuban samples, however, do not posses these features, but the morphology of the sporothecae and the spores (6–8 µm diam., warted, with scatter larger warts) enabled them confidently to be identified as this species.

Trichia affinis de Bary, in Fuckel, Nassauischen Vereins Naturk. 23–24: 336 (1870).

Material examined. Locality 11.4, on rotten wood, 19–III–1999, leg. M. Camino, D. Minter, J.M. Pérez, *HAJB 8410*. Locality 11.8, on dead trunk of *Guarea guara*, 21–XI–2001, leg. E. Bécquer, M. Camino, D. Minter & J.M. Pérez, *HAJB 8965*. Locality 13.1, on wet dead wood, 15–III–2006, leg. M. Camino, *HAJB 10828*.

Distribution: *Trichia affinis* is cited from Cuba by Camino et al. (2005, 2007). This species is new for the insular Caribbean, but most records of *T. favoginea sensu* Farr from Cuba, Dominica, the Dominican Republic, Jamaica, and Trinidad & Tobago (Minter et al. 2002) are probably *T. affinis*.

Comments – This species is characterized by its sessile, crowded, globose to subglobose sporocarps. The capillitium is formed by yellowish elaters, 5–6 µm diam., without spines, or with very short and dispersed ones. The elaters have sharp and short free ends. The spores are 10–12 µm diam., with approx. 1 µm high reticulations.

Farr (1976) considered *Trichia persimilis* P. Karst. and *T. affinis* to be synonyms of *T. favoginea* (Batsch) Pers. Farr (1958) mentioned material from Cuba of *T. favoginea* deposited in BPI, FH. In our experience, the frequent species in Cuba is *T. affinis* whereas *T. favoginea* and *T. persimilis* are both very rare in the island.

* ***Trichia agaves*** (G. Moreno, Lizárraga & Illana) Mosquera, Ladó, Estrada & Beltrán-Tej., in Lado, Cuad. Trab. Fl. Micol. Iber. 16: 82 (2001). Figs. 17–22

Material examined. Locality 13.2, on leaf of *Agave perdentata*, 21–XI–2003, leg. M. Camino, J.L. Ortiz & J.M. Pérez, *HAJB 9832*.

Distribution: This collection is a new record for Cuba and the insular Caribbean.

Comments – *Trichia agaves* is characterized by its sessile, globose to subglobose sporocarps, 0.5–1 mm diam., grouped to crowded, and often in extensive groups. The peridium is double with a thick, opaque outer layer which is

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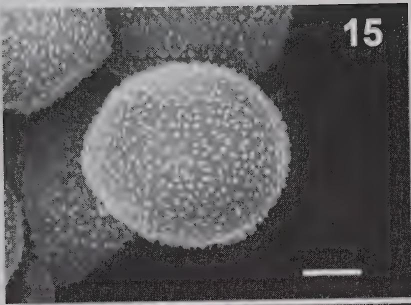
Figs. 15–16 *Stemonitopsis typhina* HAJB 10192. 15. Spore (bar = 2 µm). 16. Detail of spore ornamentation (bar = 1 µm). Figs. 17–22 *Trichia agaves* HAJB 9832. 17–20. Detail of capillitium (bar = 2 µm). 21–22. Spores (bar = 2 µm).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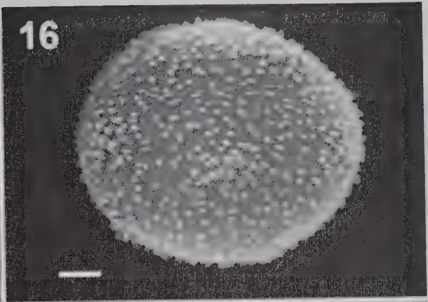
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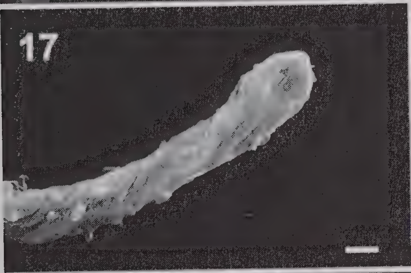
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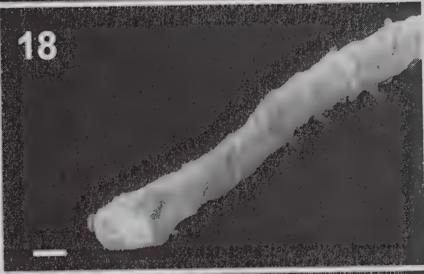
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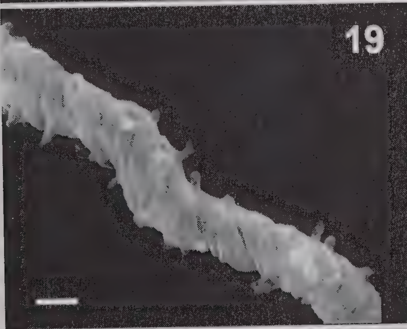
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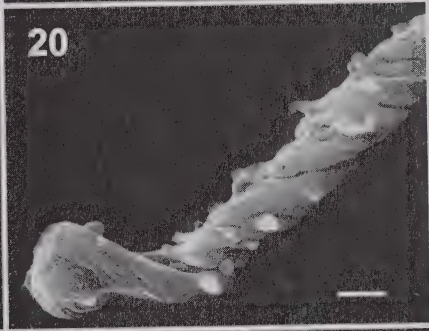
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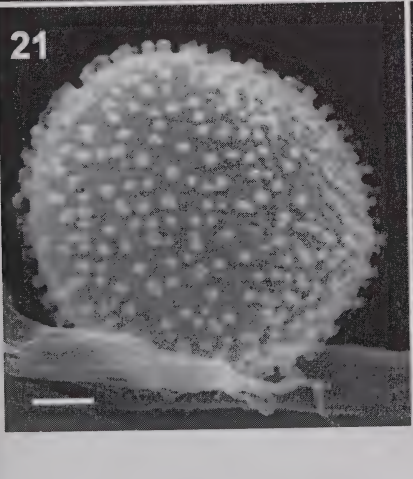
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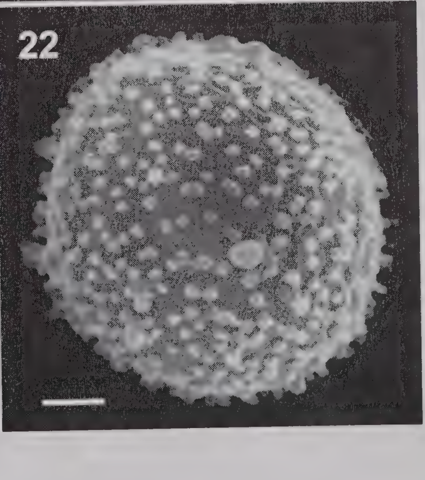
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ochraceous to deep orange when old. The thin, membranous, translucent, pale yellow inner layer is attached to the outer layer. Dehiscence is operculate or sometimes irregular. There is no columella. The capillitium is elastic, yellow by transmitted light, and orange coloured when mature. The elaters are 2–3 (–4) µm diam., flexuous, branched, with blunt free ends, and ornamented with few, 1–1.5 µm long warts, and very faint spiral bands (visible only by oil immersion). The spores are yellow in mass, light yellow by transmitted light, (11–)13–15 µm diam., globose to subglobose, warted. With SEM the capillitial elaters are shown to be ornamented with spirals and the spores with baculae.

This is a species which typically fruits on succulent plants, especially *Crassulaceae* and *Agave* (*Liliaceae)* and for this reason the epithet "*agaves*" was chosen (Moreno et al. 2000).

Tubulifera microsperma (Berk. & M.A.Curtis) Lado, Cuad. Trab. Fl. Micol. Iber. 16: 87 (2001).

≡ *Tubifera microsperma* (Berk. & M.A. Curtis) G.W. Martin, *Mycologia* 39(4): 461 (1947).
= *Licea stipitata* Berk. & Ravenel, in Berkeley & Curtis, *Proc. Amer. Acad. Arts* 4: 125 (1860), nom. illeg., non *L. stipitata* DC., 1815.
= *Tubulina stipitata* Berk. & Ravenel ex Rostaf., *Sluzowce Monogr.*: 223 (1875).

MATERIAL EXAMINED. LOCALITY 17.1, on stump, 4–V–1989, *leg.* M. Benítez, H.D. Gómez, H. Saralegui & C. Panfet, *HAJB 6346.* LOCALITY 20.1, on rotten bark with mosses, 7–VII–2004, *leg.* M. Camino, *HAJB 10404.*

DISTRIBUTION: This species was cited from Cuba by Berkeley (1869) as *Licea stipitata*, by Massee (1892) as *Tubulina stipitata*, and by Farr (1976), Camino (1998b) and Camino & Pérez (2001) as *Tubifera microsperma.* In the insular Caribbean this species has been reported (as *Tubifera microsperma*) from Cuba, Dominica, Guadeloupe, Jamaica, Puerto Rico and Trinidad & Tobago (Minter et al. 2002).

COMMENTS – This species is easily identified by its pedicelate aethalia. The inside of the peridium has protuberances in the form of short tubes that resemble the suckers of octopus tentacles, easily visible by transmitted light and SEM. The spores are small, with a completely reticulated hemisphere.

Discussion

In this study, 50 species of myxomycetes were identified from 118 specimens obtained as field collections and from moist chamber cultures in 58 localities throughout Cuba. Of this total, 25 species are here reported for the first time from Cuba with 10 representing new records for the insular Caribbean, Subreino Neotropical (Takhtajan et al. 1986).

The 50 species represent 12 families of myxomycetes: *Arcyriaceae* (*Perichaena*: 1 species), *Clastodermataceae* (*Clastoderma*: 1 species), *Cribrariaceae* (*Cribraria*: 4 species), *Dianemataceae* (*Calomyxa*: 1 species), *Dictydiaethaliaceae* (*Dictydiaethalium*: 1 species), *Didymiaceae* (*Diderma*:

2 species; *Didymium*: 5 species), *Echinosteliaceae* (*Echinostelium*: 1 species), *Liceaceae* (*Licea*: 3 species), *Physaraceae* (*Craterium*: 2 species; *Physarum*: 13 species), *Reticulariaceae* (*Lycogala*: 1 species; *Reticularia*: 1 species; *Tubulifera*: 1 species), *Stemonitidaceae* (*Comatricha*: 2 species; *Lamproderma*: 1 species; *Macbrideola*: 1 species; *Stemonitis*: 4 species, *Stemonitopsis*: 1 species) and *Trichiaceae* (*Hemitrichia*: 2 species; *Trichia*: 2 species). The families that have the greatest diversity of species are: *Physaraceae* and *Stemonitidaceae*, followed by *Didymiaceae*, *Cribrariaceae*, *Trichiaceae*, *Reticulariaceae* and *Liceaceae*. The remaining families are represented by only one genus and one species.

Species of the *Physarales* predominate, an aspect already noted by other authors for tropical and subtropical forests of the American continents (e.g., Schnittler & Stephenson 2000). Of the 50 studied species most have a cosmopolitan distribution. Nevertheless *Craterium paraguayense*, *Hemitrichia calyculata*, *Physarum flavicomum*, *P. globuliferum*, *P. gyrosum*, *P. nicaraguense*, *P. roseum*, *P. stellatum* and *Tubulifera microsperma* appear to be mainly Neotropical. In addition, a number of species can be considered as rare or infrequently noted. These include *Comatricha anomala*, *Cribraria confusa*, *Licea pseudoconica*, *Reticularia jurana* and *Trichia agaves*. In this study, members of genus *Arcyria* were not collected, although some, such as *A. cinerea* and *A. denudata*, are very common on fallen wood in tropical forests (Stephenson et al. 2003). *Trichia agaves* is a species that develops on succulent plants (mainly *Cactaceae* and *Agavaceae*). Seven species considered herein produced sporocarps in moist chamber cultures. These were *Licea biforis*, *L. pedicellata*, *L. pseudoconica*, *Calomyxa metallica*, *Comatricha anomala*, *Echinostelium minutum* and *Macbrideola cornea*. In terms of substrata, the foliicolous species which were recorded in this study were *Craterium leucocephalum*, *C. paraguayense*, *Diderma effusum*, *Didymium bahiense*, *D. clavus*, *D. difforme* and *D. nigripes*. The various species collected from the genus *Cribraria* occurred mainly on wood and bark in damp places, often in association with bryophytes. Collections of *Stemonitales* and *Hemitrichia calyculata* were clearly lignicolous. The frequent occurrence of *Hemitrichia serpula* on palms is noteworthy, in particular its occurrence on petioles and rachides of *Roystonea regia* (Royal Palm, *Arecaceae*). *Lycogala epidendrum*, *Physarum globuliferum*, *P. stellatum* and *Stemonitis fusca* were also found on these substrata.

Provinces of Cuba with many species are: Ciudad de la Habana, Pinar del Río, Sancti Spíritus and Santiago de Cuba. Fewer species have been recorded from Camagüey, Guantánamo, Granma, Holguín and La Habana, while there are no records at all from Matanzas, Villa Clara, Ciego de Ávila and Las Tunas. These are all in or adjacent to the central zone of the island, where the climate tends to be drier and the vegetation more scanty, factors not very suitable for growth of myxomycetes. Nevertheless, the central zone also contains the “Sierra de Escambray", where the climate is less dry, and the vegetation more suitable for myxomycetes. It would be rewarding to explore that area more fully.

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Mucor guilliermondii (*Mucorales*): a rare species found in herbivore dung from Neotropics

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Abstract — *Mucor guilliermondii* was isolated for the first time in Neotropics, from tapir (*Tapirus terrestris*) dung collected at the Reserva Ecológica de Dois Irmãos (8°7'30" S and 34°52'30" W), located in Recife, State of Pernambuco, Northeast Brazil. An identification key for species of *Mucor* studied in Brazil is provided.

Key words — *Zygomycetes*, *Mucoraceae*, taxonomy

Introduction

Mucor includes about 80 cosmopolitan species and is the most representative and studied genus of *Mucoraceae* (Domsch et al. 1995). This genus belongs to the subphylum *Mucoromycotina* (Hibbett et al. 2007), order *Mucorales* family *Mucoraceae* (Benny 2005) and contains many coprophilous and noncoprophilous species (Krug et al. 2004).

Mucor guilliermondii was described by Nadson & Philippov (1925) from *Periplaneta americana* dung in Russia and re-described by Schipper (1978). There are few reports of isolation from soil in Malaysia (IMI 350568) and from humus horizon in Belgium (MUCL 38359). This species is differentiated from the other *Mucor* species by the production of elongated-conical columellae with extremely small or absent collar and ellipsoidal, cylindrical to reniform sporangiospores, generally with a droplet at each end (Schipper 1978).

The aim of this work was to describe *M. guilliermondii* isolated from tapir dung in Recife, PE, and to provide an identification key for *Mucor* species studied in Brazil.

Materials and methods

The samples of tapir (*Tapirus terrestris*) dung were collected at Reserva Ecológica de Dois Irmãos (8°7'30"S and 34°52'30"W), which includes a Zoological Park and is located in Recife, State of Pernambuco, Northeastern Brazil. The area contains 387 ha and is an Atlantic Forest Ecological Reserve.

The samples of dung were collected with a sterilized spatula, placed in plastic bags, taken to the laboratory and incubated in moist chamber at 28°C ± 2°C for 7 days.

Fragments of mycelium were removed directly from the samples at the stereomicroscope and transferred to the Petri dishes with potato dextrose agar (PDA) (Lacaz et al. 2002) plus chloramphenicol (80 mg/L). Identification was based on macroscopic (color, aspect and diameter of the colonies) and microscopic (microstructures) characters according to Nadson & Philippov (1925) and Schipper (1978).

Taxonomy

Mucor guilliermondii Nadson & Philippov,
Rev. Gén. Bot. 37: 450 (1925) Fig. 1 a–d

Colony with limited growth after 6 days at 26°C in PDA, 6.5 cm diam and 3 mm height. Colony white with cottony aspect, irregular edges and yellowish reverse. Aroma lightly sweet. SPORANGIOPHORES not ramified, 2.5–6 µm diam, erect, some bending, soon collapsing. SPORANGIA hyaline with vitreous aspect, yellow, globose and subglobose to lightly depressed, 14.5–52.5 µm diam with smooth, transparent and deliquescent wall. COLUMELLAE elongated-conical, rare subglobose and ellipsoidal with lightly incrusted wall, 15–30 × 5.5–14.5 µm, majority with 15–20 × 5.0–8.5 µm, small or absent collar. SPORANGIOSPORES hyaline, smooth walled, 3.5–8 × 2.0–4.5 µm, ellipsoid and cylindrical to reniform, some irregular, with a droplet at each end. Some cells may contain more than two droplets. CHLAMYDOSPORES globose, 12.5–23 µm, subglobose, cylindrical and doliiform, 10–22.5 × 8–22 µm. ZYGOSPORES not observed.

HABITAT: Tapir dung (*Tapirus terrestris*).

GEOGRAPHIC DISTRIBUTION: Russia (CBS 174.27), Malaysia (IMI 350568), Belgium (MUCL 38359). This is the first report in Neotropics.

SAMPLE INFORMATION: Brazil, Pernambuco, Recife, Reserva Ecológica de Dois Irmãos, May/06, A. L. C. M. A. Santiago (URM5848).

REMARKS: The characteristics of the strains of *M. guilliermondii* reported here show a close similarity with the descriptions of Nadson & Philippov (1925) and Schipper (1978). However, differences on colony color and diameter of sporangiophores were observed. Nadson & Philippov (1925) reported wider

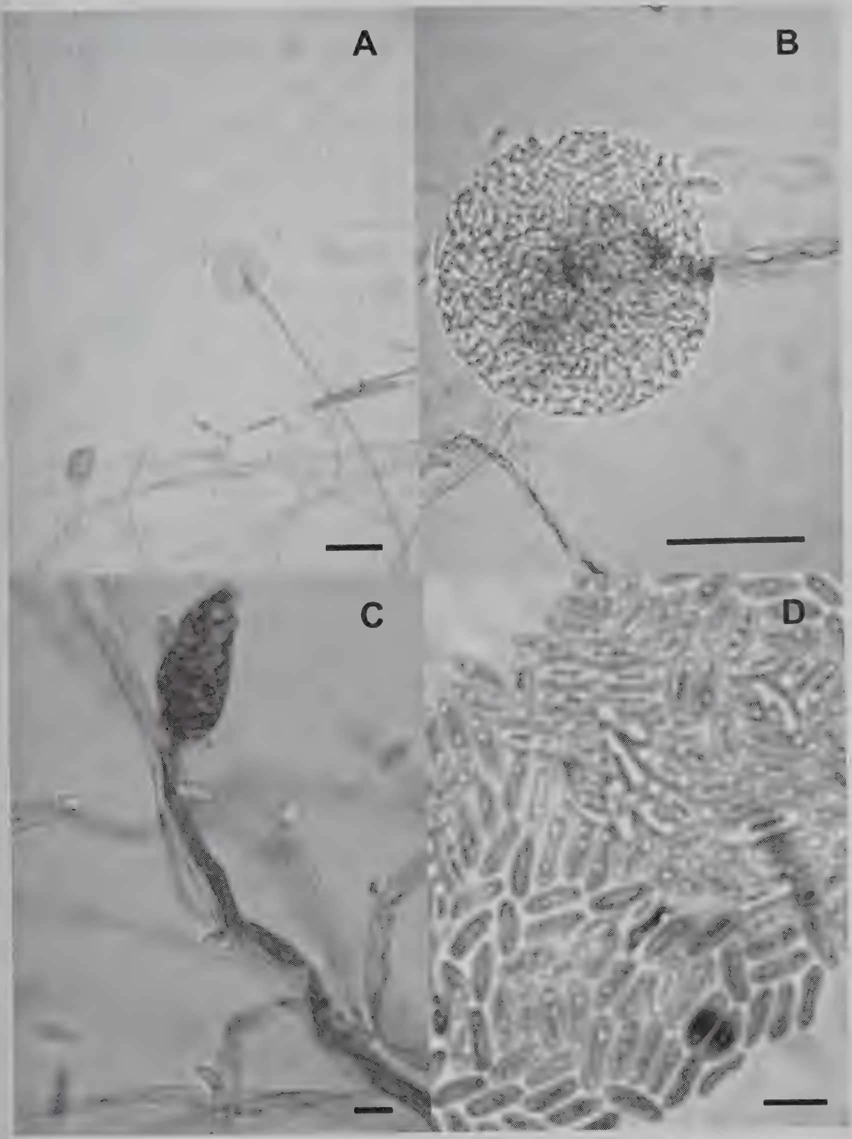

Fig. 1 *Mucor guilliermondii*
A) Sporangiophore; B) Sporangium; C) Columella; D) Sporangiospores.
Scale bars: A = 40 µm; B = 20 µm; C = 4 µm; D = 5 µm.

sporangiophores (7–10 µm diam) in relation to the ones described by Schipper (1978; up to 7 µm diam) and those described in this manuscript (2.5–6 µm diam). The colony color may vary from white (Nadson & Philippov 1925) to pale gull gray (Schipper 1978). Although sporangiospores usually show a droplet at each end, according to Nadson & Philippov (1925) the number of droplets may vary (3, 4 or more).

Mucor guilliermondii was treated as a synonym of *M. subtilissimus* Oudem. by Zycha (1969). According to Schipper (1978) 'the almost obclavate columellae in *M. guilliermondii* are hard to reconcile with the columellae of *M. subtilissimus*, which were described by Oudemans (1898) as being globose'. The globose columellae on *M. subtilissimus* was also observed by Alves et al. (2002) who pointed out that *M. subtilissimus* sporangiophores present a constriction next to young sporangia or swelling 50 µm below the columellae, which are not visualized in *M. guilliermondii*.

This manuscript reports for the first time the occurrence of *Mucor guilliermondii* in Neotropics, contributing with the knowledge of *Mucorales* distribution. In Brazil, other species of *Mucor* such as *M. circinelloides* Tiegh., *M. fuscus* Bainier, *M. genevensis* Lendn., *M. hiemalis* Wehmer, *M. mousanensis* Baijal & B.S. Mehrotra, *M. mucedo* L., *M. piriformis* A. Fisch., *M. plumbeus* Bonord., *M. racemosus* Fresen., *M. subtilissimus*, and *M. variosporus* Schipper have been isolated from herbivore dung (Batista et al. 1961a, b, c; Trufem 1984, Trufem & Viriato 1985, Alves et al. 2002).

Identification key for species of *Mucor* from herbivore dung in Brazil

1. Zygospores present in monosporic cultures .... ***M. genevensis***
1. Zygospores absent in monosporic cultures 2

2. Mycelia delicate, sporangiospores with one or more droplets at each end 3
2. Mycelia vigorous, sporangiospores without droplets at the ends 4

3. Columellae globose, sporangiophores with a constriction next to young
 sporangia or swelling 50 µm below the columellae .... ***M. subtilissimus***
3. Columellae elongated-conical, sporangiophores not as above ..... ***M. guilliermondii***

4. Sporangia with persistent wall 5
4. Sporangia with deliquescent wall 6

5. Columellae globose, obovoid; sporangiospores variable in shape and size
 .... ***M. variosporus***
5. Columellae elongated-conical or ellipsoidal; sporangiospores ellipsoidal,
 regular in size .... ***M. mousanensis***

6. Sporangia often more than 150 µm diam 7
6. Sporangia often less than 150 µm diam 8

7. Sporangiospores ellipsoidal up to 10 µm in length; rapid growth on cherry agar
 or acid beerwort agar .... ***M. piriformis***
7. Sporangiospores cylindrical-ellipsoidal, often over 10 µm in length; restricted
 growth on cherry agar or acid beerwort agar .... ***M. mucedo***

8. Sporangiophores unbranched or weakly sympodially branched 9
8. Sporangiophores repeatedly sympodially branched............................10

9. Columellae globose; sporangiospores ellipsoidal, fusiform .....***M. hiemalis*** f. ***luteus***
9. Columellae subglobose with a truncate base, some subglobose; sporangiospores ellipsoidal, sometimes flattened at one side ....***M. hiemalis*** f. ***hiemalis***

10. Chlamydospores abundant in sporangiophores........***M. racemosus*** f. ***chibinensis***
10. Chlamydospores rare in sporangiophores.....................................11

11. Sporangiospores globose and globose to subglobose, rare irregular.............12
11. Sporangiospores subglobose and ellipsoidal, some globose...................13

12. Sporangiophores branching sympodially and monopodially; columellae often with projections .... ***M. plumbeus***
12. Sporangiophores branching sympodially; columellae rarely with projections .... ***M. fuscus***

13. Colonies white at first, later gray at 26°C in PDA.............................14
13. Colonies white at first, later brown at 26°C in PDA...........................15

14. Sporangiospores subglobose, some globose 7 μm diam .... ***M. circinelloides*** f. ***janssenii***
14. Sporangiospores ellipsoidal, 5–11.2 × 2.5–6.2 μm ....***M. circinelloides*** f. ***griseocyanus***

15. Columellae obovoid to ellipsoidal, globose in the smaller sporangia ....***M. circinelloides*** f. ***circinelloides***
15. Columellae globose.............................***M. circinelloides*** f. ***lusitanicus***

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The genus *Stereum* in Israel

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Abstract — A study of Israeli *Stereum* species diversity resulted in four species: *Stereum gausapatum*, *S. hirsutum*, *S. sanguinolentum*, and *S. subpileatum*. A new form, *S. hirsutum* f. *lobulatum*, is described from the species complex, and *S. gausapatum* and *S. sanguinolentum* are recorded as new species for Israeli mycobiota. Taxa are described and microstructural features are illustrated based on specimens collected from northern Israeli forests. Notes on host preference, morphological variability, distribution, and taxonomic relationships are provided. A key to Israeli *Stereum* species is given.

Key words—Mediterranean, stereoid fungi, polymorphism, taxonomy

Introduction

Its xerophilic habit makes the genus *Stereum* (*Stereaceae*, *Russulales*) a highly characteristic indicator for arid mycotas. This genus includes white-rot fungi inhabiting fallen or standing branches, trunks, and stumps representing a broadly diverse selection of broadleaved and coniferous trees. Their economic importance lies in their wood-destroying properties and carbon recycling of arid forest ecosystems (Overholts 1939, Woon & Jung 1999).

The stereoid morphotype covers annual to perennial, tough-leathery substipitate to resupinate fruitbodies with a more or less even hymenophore. Generically, the *Stereum* pileal covers are trichodermoid, often transforming to a fomitoid crust. The hymenium is variably colored, occasionally staining yellow-orange or red when injured. Cross-sections of the cream-colored context reveal thin dark reddish deposits between the tomentum and fruitbody core. Russuloid pseudocystidia with refractive contents and weakly amyloid spores are characteristic at the microscopical level. The hyphal system is variously described as dimitic or monomitic, but most species have a pseudodimitic hyphal system dominated by thick-walled hyphae with living protoplasts. All hyphae are densely packed so that the fruitbodies are rather hard.

The concept of *Stereum*, adopted by Persoon (1794) and Fries (1838), was long used as an infrageneric division of *Thelephora* Ehrh. On the other hand, the concept of this union was rather broad. After generic separation and intensive microscopical studies, the concept of *Stereum* became increasingly narrow. Lentz (1955), Donk (1957), Boidin (1958a, b, 1959a, b, 1960), Pouzar (1959), Parmasto (1968), Welden (1971), and Chamuris (1988) segregated *Stereum* into smaller genera, thereby making the remaining genus a more homogeneous group. However, some of these segregate genera (e.g., *Haematostereum* Pouzar, *Xylobolus* P. Karst. emend. Boidin) have been "merged" into the core *Stereum* group, creating additional taxonomical problems. Some *Xylobolus* characteristics — such as amyloid binucleate basidiospores, hymenial acanthophysoid elements, and homothallism — are also basic generic characters for *Stereum*, suggesting that segregation of the genus has been premature.

Species concepts within *Stereum* are complicated by a lack of stable character patterns. Basidiocarp shape, type of tomentum, and presence of acanthohyphidia and conducting hyphae (Jülich & Stalpers 1980).

Modern molecular investigations place *Stereum* in the russuloid clade, which fully corresponds with microscopic evidence. Characteristics such as amyloid reactivity of the spore wall and the presence of gloeoplerous and lactiferous hyphae in most *Stereum* species are considered homologous with other russuloid taxa (Larsson & Larsson 2003, Larsson 2007).

The genus *Stereum* is distributed worldwide, with many widespread species following the distribution of their hosts from the boreal zone of Europe and North America into the arid areas of Africa, Asia, Australia, and the Middle East (Binyamini 1982, 1984; Breitenbach & Kränzlin 1986; Chamuris 1988; Ginns & Lefebvre 1993).

The history of *Stereum* research in Israel began with Binyamini (1982), who, in his fourth paper on Israeli lignicolous *Aphyllophorales*, recorded *Stereum hirsutum* and *Xylobolus subpileatus* (later described in Binyamini 1984) as species new to the area. *Stereum hirsutum*, considered a complex by many authors due to its great morphological variability, occurs on various hardwood substrata, shows a high ecological tolerance, and is also widespread in northern Israeli broadleaf forests. In contrast, *Stereum* (*Xylobolus*) *subpileatum* has been found only once growing on *Quercus calliprinos* in the Samarian forests. We have also found *Stereum gausapatum* inhabiting *Q. calliprinos* stumps in the

Israeli mountain forests of the Golan Heights. This species follows its host, usually oak, in Europe, Asia, Australia, and North America (Breitenbach & Kränzlin 1986). We present the first reports of *Stereum gausapatum* as well as the conifer-inhabiting *S. sanguinolentum* (found growing on fallen pine wood in the Golan Heights) for Israel below.

Material and methods

Fruitbody morphology was examined under light/dark field using a Carl Zeiss Axiostar 1122-100 microscope. Measurements were made using an immersion objective; 30 spores were measured for each specimen. The highest and lowest 5% spore measurements (given in parentheses) were excluded from each size variation range as outliers. Tissues were mounted in 10% potassium hydroxide (KOH) aqueous solution and Melzer's reagent for microscopical analyses. The material used in our analyses can be found in the herbarium of the Institute of Evolution, University of Haifa (Haifa, Israel, HAI). A map (Fig. 1) shows the Israeli distributions of each newly recorded species were distributed (Feinbrun-Dothan & Danin 1998).

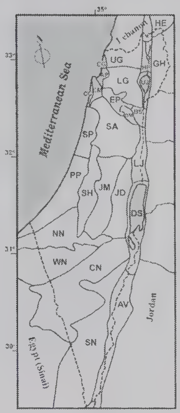

Fig. 1. Accepted abbreviations of nature regions of Israel: **AP** – Akko Plain; **AV** – Arava Valley; **BS** – Beit Shean Valley; **CC** – Carmel Coast; **CG** – Coast Galilee; **CM** – Carmel Mount; **CN** – Central Negev; **DS** – Dead Sea Area; **EP** – Esdraelon (Yizre'el) Plain; **GH** – Golan Heights; **GM** – Gilboa Mount; **HE** – Hermon Mount; **HP** – Hula Plain; **JD** – Judean Desert; **JM** – Judean Mts.; **LG** – Lower Galilee; **LJ** – Lower Jordan Valley; **NN** – Northern Negev; **PP** – Philistean Plain; **SA** – Samaria; **SH** – Shefela; **SN** – South Negev; **SP** – Sharon Plain; **UG** – Upper Galilee; **UJ** – Upper Jordan Valley; **WN** – Western Negev.

Taxonomic descriptions

Stereum gausapatum (Fr.) Fr., Hymenomyc. Eur.: 638, 1874. Figs. 2–3
≡ *Thelephora gausapata* Fr., Elench. Fung. 1: 171, 1828.

Basidiocarps annual, coriaceous, sessile to resupinate, normally effused-reflexed, 3–15 cm in extent, on vertical substratum found as imbricate dimidiate pilei merging into board-like patches. Abhymenial surface tomentose to strigose-hirsute; slightly zonate, rust-brownish with white-cream, and thin inflexed undulating margin. Hymenial surface even to somewhat tuberculate, cracking, brittle and pale-brown when fresh, but gray-brown when dry; when injured, fresh basidiome bruising red. Context thin, homogeneous, 0.5–1 mm. thick, cream-colored, in dry specimens without an evident deposit between tomentum and context.

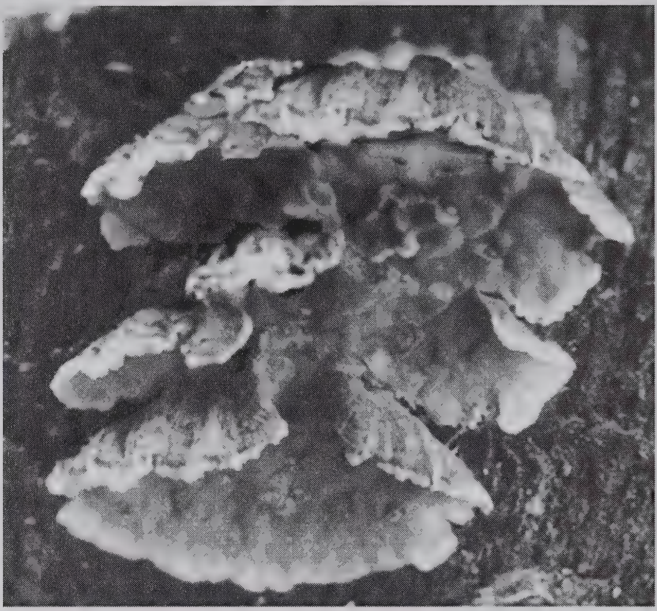

Fig. 2. *Stereum gausapatum* growing on *Quercus calliprinos* stump in GH, Israel. Scale bar = 1 cm (Photo V.F. Malysheva).

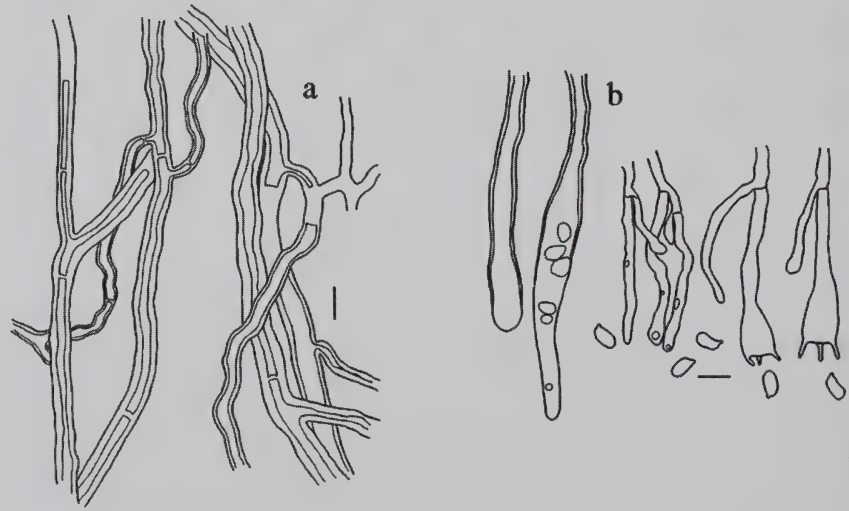

Fig. 3. Microscopic structures of *Stereum gausapatum*: a – hyphae; b – hymenial fragment showing slenderly thick-walled pseudocystidia among cylindrical basidioles, basidia, and basidiospores. Scale bar = 10 µm.

Hyphal system pseudodimitic. Subhymenial hyphae strongly interwoven, thus individual hyphae hardly seen, while contextual hyphae are somewhat loose. Generative hyphae septate, thin- to slightly thick-walled, 2–4 µm diam, branched and hyaline. Pseudoskeletal hyphae thick-walled, hyaline to yellowish with oily contents inside, slenderly branched, 4–8 (mostly 4–5) µm diam. Conducting hyphae similar, but without septation, with chrysescent contents. Cystidia not seen, but cystidia-like hyphal ends (pseudocystidia) numerous, cylindrical to subcylindrical, thin- to slightly thick-walled, 2–7 µm wide (with basal inside walls 1–1.5 µm thick), but apically thin-walled, with brownish oily contents. Basidioles cylindrical, thin-walled, 2–3 µm diam, projecting up to 10 µm above hymenium. Basidia narrowly clavate to clavate, 43–55 × 6–10 µm, 4-spored, without a basal clamp. Basidiospores ellipsoid-cylindrical, hyaline, smooth, thin-walled, (6–)6.5–7.9 × 3–3.8 µm, amyloid.

Found growing on *Quercus calliprinos* in the North of Israel (Fig. 4).

General distribution and habitat. *Stereum gausapatum* occurs mostly in oak zones on *Quercus*, *Castanea*, and *Carpinus* species. Basidiomata develop on dead stems, rotten stumps, logs, or trunks. Associated with a white rot (Ginns & Lefebvre 1993). Its general distribution according to our knowledge includes: Europe (Austria, Belgium, Denmark, Estonia, France, Germany, Georgia, Greece, Norway, Portugal, Russia, Spain, Sweden, Ukraine); Middle East (Israel, Turkey), Asia (Azerbaijan, Japan, South Korea); North America (Mexico, USA); South America (Panama).

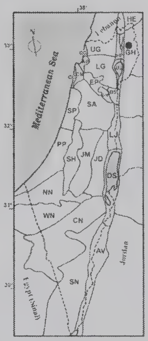

Fig. 4. Distribution of *Stereum gausapatum* in Israel.

Note. *Stereum gausapatum* was considered one of the "bleeders", along with *S. sanguinolentum* and *S. rugosum* Pers. and therefore placed into *Haematostereum* by Pouzar (1959). The bleeding reaction in fresh specimens appears upon hymenial surface injury and is caused by inner-colored exudates of the numerous pseudocystidia present in the hymenium of these species (Fig. 17). Due to this particular fact, *S. gausapatum* can be confused with *S. rugosum*, which when bruised also stains red and in addition shares the same habitat, however differs by its stratified perennial hymenium, larger spores, and presence of acanthohyphidia. Other species sharing a common habitat with *S. gausapatum*, are *S. hirsutum* and *S. ostrea* (Blume & T. Nees) Fr. In the field, *S. gausapatum* can be distinguished from *S. ostrea* by densely hirsute and thicker pilei (Overholts 1939), but, microscopically, *S. gausapatum* does not possess acanthohyphidia. In Israel, *S. gausapatum* may be confused with specimens belonging to *S. hirsutum*-complex because they share the same habitat, have similar spore sizes, and, in some specimens, turn red when injured during their active growth phase. However, *S. hirsutum* has thick-walled pseudocystidia and usually acute hyphidia, while the pseudocystidia in *S. gausapatum* have rather thin walls: less than 1.5 µm in diam. (Chamuris 1985, 1988). According to Jülich & Stalpers (1980), within *S. gausapatum*, the dimension of the spores given by European authors is always larger than those given by American authors.

SPECIMENS EXAMINED: **ISRAEL. GH**, Massada Forest, *Quercus calliprinos* forest, on *Quercus* stump, 07.03.2007, leg. & det. D. Ţura, I. Zmitrovich et V. Malysheva (HAI 0114).

Stereum hirsutum (Willd.) Pers., Observ. Mycol. 2: 90, 1800 ('1799'). FIGS. 5–9
≡ *Thelephora hirsuta* Willd., Fl. Berol. Prodr.: 397, 1787.

BASIDIOCARPS annual to perennial, usually sessile to effused-reflexed with narrow to broadly prostrate base or totally resupinate and several centimeters in extent. Pilei semicircular, dimidiate or flabelliform to irregular, often umbonate, up to 70 × 50 × 1–2 mm; membranous-elastic when fresh and ceraceo-coriaceous when dry. When broadly attached, in most cases with confluent pilei, the single pilei have an imbricate arrangement. ABHYMENIAL SURFACE hirsute to hispid, yellow-ochraceous or grayish-white, in older specimens often covered by green algae or with a reddish-brown cutis exposed towards the attachment zone, more or less zonate. When zonate, usually with narrow dark bands alternating with wider and lighter colored ones (zonation in some specimens may be more prominent towards margin, where cutis is visible as a narrow glabrous band). Margin wavy, sometimes radiately plicate, thinning outwards, usually whitish-cream to gray. HYMENIAL SURFACE smooth to slightly tuberculate, often with radial concentric ridges; light-yellow to orange-grayish, when old hymenium turns gray, in some specimens growth may continue on the same-aged basidiocarp; thus, sometimes marginal hymenium appear to be thicker and lighter in color. CONTEXT thin, whitish-cream; in cross section, with a very thin red-brownish deposit between tomentum and context, barely observable in some specimens.

HYPHAL SYSTEM pseudodimitic. Generative hyphae simple septate, thin-walled, mostly 2–3µm diam, branched and hyaline; pseudoskeletal hyphae thick-walled, rarely septate, 4–8 µm diam, unbranched to slightly branched, with oil-drops and pale yellowish contents in KOH. CYSTIDIA not seen, but cystidia-like hyphal ends (pseudocystidia) present. PSEUDOCYSTIDIA abundant, cylindrical to subcylindrical, sometimes medially inflated, thick-walled, except an apical part with basal wall 3–4 µm thick. HYPHIDIA acuminate, mostly cylindrical, thin- to slightly thick-walled, 2–3 µm in diam. BASIDIA slenderly-clavate, 25–35 × 3.5–4 µm, 4-spored, without a basal clamp. BASIDIOSPORES ellipsoid-cylindrical, hyaline, thin-walled, even, often with internal oil-drops, 4–6.5(–7) × 3–3.5 µm, amyloid.

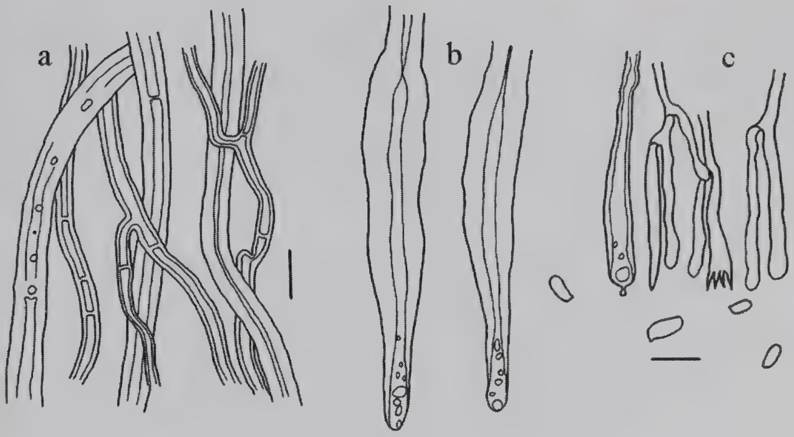

Fig. 5. Microscopic structures of *Stereum hirsutum*:
a – hyphae; b – thick-walled pseudocystidia; c – hymenial fragment showing pseudocystidia among acute-cylindrical hyphidia, basidia, and basidiospores.
Scale bar = 10 µm.

General distribution and habitat. The species within the *Stereum hirsutum*-complex are generally known to grow on bark and wood of trunks, twigs, or stumps of a wide range of dead or living deciduous trees. According to present-day knowledge, the members of this complex are widespread and common in several countries: Europe (Austria, Croatia, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Macedonia, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Spain, Sweden, UK, Ukraine); Middle East (Israel, Turkey); East Asia (Mongolia, Japan, South Korea); North America (Canada, USA); South America (Colombia, Costa Rica, Dominican Republic, Venezuela); Southern Hemisphere (Australia, New Zealand); Africa (Morocco, Tanzania); Greater Antilles (Jamaica).

Note. Some authors treat *Stereum hirsutum* as a complex that shares a common or similar inner structure but exhibits different morphological forms; other authors find “reliable” taxonomic features to split this complex into separate species. However, some specimens, depending on biotic and abiotic factors of their habitat in various geographic biomes, show some stable morphotypes.

During its active growth, hymenium in some fruitbodies turns yellow-orange to red when bruised; thus, in the field, they might be confused with *S. rugosum* and *S. gausapatum*. Therefore, careful morphological examination is needed. Because of its multiplicity of forms, according to Breitenbach & Kränzlin (1986), old specimens of *S. hirsutum* can be confused with *S. ochraceoflavum* (Schwein.) Fr. Although both species share the same substrata, *S. ochraceoflavum* preferentially colonizes twigs and clippings, while *S. hirsutum* colonizes trunks, crevices, and thick branches and thus apparently produces thicker fruitbodies.

Chamuris (1988) cites the following important stable characters for the North American *S. hirsutum* (all also found in Israeli examined specimens): the presence of cutis, broad substratum preference, mostly acuminate hyphidia, thick-walled pseudocystidia with basal wall thickness ≥ 2 µm wide, and conducting hyphae with yellow contents that turn brownish-orange in Melzer's reagent.

Stereum hirsutum is one of the most common hardwood-inhabiting species in Israel. The variable morphologies exhibited by the species in northern Israeli forests are compared in TABLE 1.

TABLE 1. Fruitbody variability in *Stereum hirsutum*-complex in Israel

MORPHOTYPES	BASIC CHARACTERISTICS
Strongly plicate, actively growing type HAI 0141 (FIG. 6)	**fruitbodies** strongly plicate, imbricate, narrowly to sessile attached; **abhymenial surface** tomentose-strigose ocher-pale brownish, towards attachment zone covered by green algae or with a glabrous reddish brown cutis; **hymenium** even, with radially concentric ridges, yellowish-orange. Note: The yellow to reddish bruising hymenium (sometimes, when fresh) suggests an actively growing basidiocarp; usually, in such cases, the abhymenial and hymenial surfaces show lighter colors compared to aged fruitbodies (Fig. 7).
Aged fruitbody type HAI 0119 (FIG. 7)	**fruitbodies** narrowly attached to sessile, dimidiate, flabelliform; **abhymenial surface** white-gray, zonate, tomentose-strigose, with cream- colored margin and often glabrous, blackish-brown cutis towards attachment zone; **hymenial surface** yellow-orange to gray, smooth. Note: the hard, dry fruitbodies, the glabrous, brown-blackish visible cutis, often covered by green algae and the presence of grayish color on hymenial and abhymenial surfaces resemble the main features of aged fruitbodies.
Uneven hymenophore type HAI 0138 (FIG. 8)	**fruitbodies** effused-reflexed, narrowly attached, confluent; **abhymenial surface** zonate, mated-strigose, grayish; **hymenial surface** even-tuberculate beset with minute, irregular, lighter colored folds, which actually resemble small, rising individual pileoli with light-colored patches on a grayish background. Note: only two samples with this type of deviant hymenial surface, were found in Israel in different localities.
Tomentose abhymenial surface type HAI 0137 (FIG. 9)	**fruitbodies** imbricate, broadly to narrowly attached in appearance, 90 × 17 × 1 mm thick, confluent; an individual pilei with its own attachment point; **abhymenial surface** tomentose, tomentum entirely covering the upper surface including short stipe, zonate; **hymenial surface** even, light yellowish-orange to grayish towards attachment point. Note: the soft tomentum covering the entire upper surface and the warm light colors make this specimen highly distinguishable from the other samples of *Stereum* that we found.

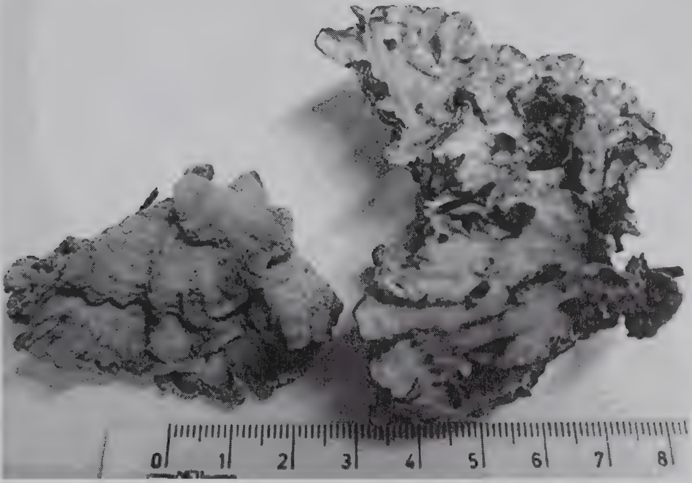

Fig. 6. *Stereum hirsutum* fruitbody: strongly plicate, actively growing type (explanation in Table 1). Scale bar = 1 cm.

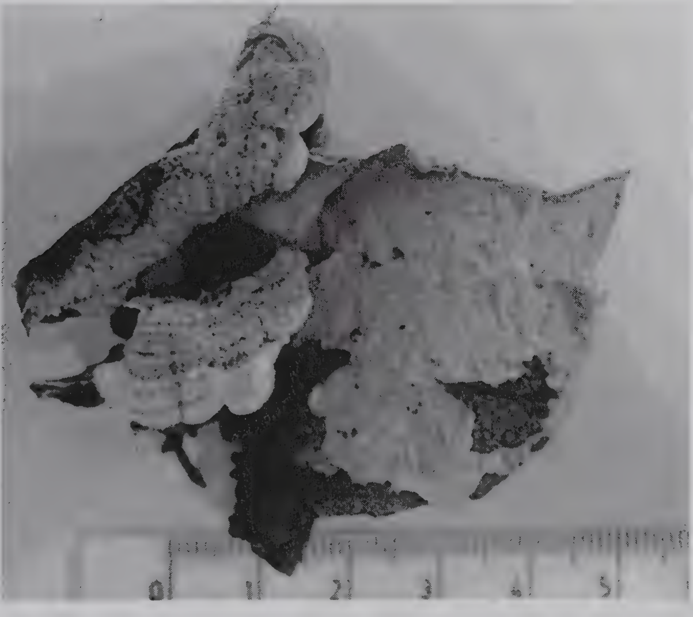

Fig. 7. *Stereum hirsutum* fruitbody: aged fruitbody type (explanation in Table 1). Scale bar = 1 cm.

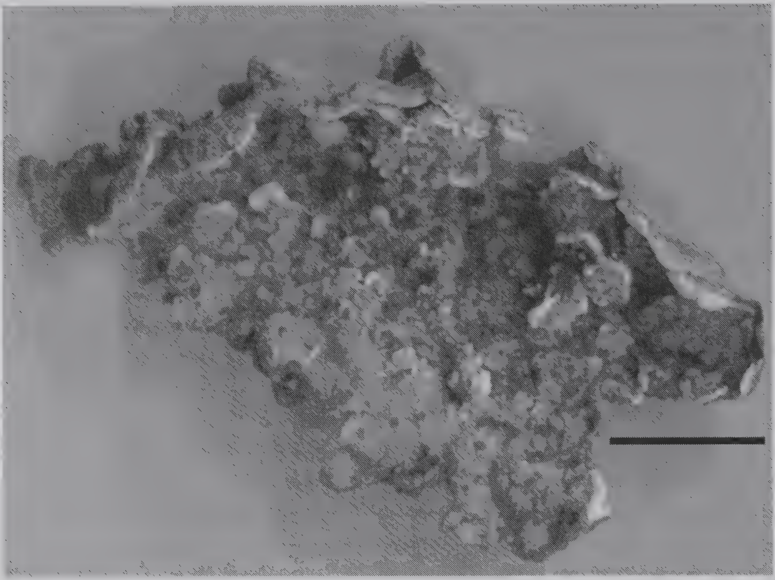

Fig. 8. *Stereum hirsutum* fruitbody: uneven hymenophore type(explanation in Table 1). Scale bar = 1 cm.

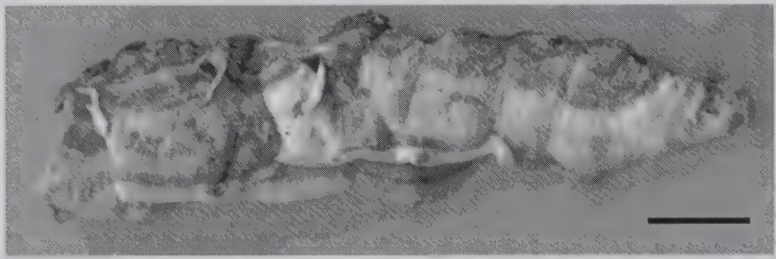

Fig. 9. *Stereum hirsutum* fruitbody: tomentose abhymenial surface type (explanation in Table 1). Scale bar = 1 cm.

Chamuris (1988) suggests that *S. subtomentosum* Pouzar gradually merges into *S. hirsutum*. Indeed, in boreal areas, specimens characterized by applanate symmetrical pilei with dull-colored hymenium can be found, but the presence or absence of a strigose abhymenial surface greatly complicates species attribution. However, as Israeli materials, despite their variability, do not include *S. subtomentosum*-like morphotypes, this taxon may be considered absent in Israel.

The *S. hirsutum* species complex is widely distributed in North Israel (Fig. 10).

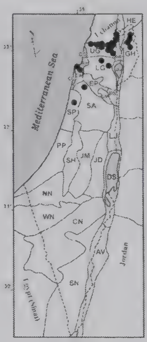

Fig. 10. Distribution of *Stereum hirsutum*-complex in Israel.

Many Israeli specimens of *S. hirsutum* exhibit longitudinally expanded lobate processes, a very interesting feature that is seen elsewhere only in *S. ostrea* (incl. *S. lobatum*) and *S. insignitum* Quél. Its strigose pilei with a black line under the tomentum and the absence of acanthohyphidia, confirms the identification of the Israeli material as *S. hirsutum*, yielding an ecotype parallel to *S. ostrea* and *S. insignitum*. As this pattern is very distinguishable, we propose a new form for this polymorphic species:

Stereum hirsutum* f. *lobulatum Țura, Zmitr. & Wasser, **f. nov.** Figs. 11–12

Mycobank MB 506905

Basidiomata stereoidea, perennia, basi angustata, lobulata, elongata, ad marginem undulata et confluenta. Superficio strigosa, zonata et undulata, basi cinerascens, ad marginem ochraceo-flava. Hymenium laeve, sed radiately costatum, basi cineraceo-flavum, ad marginem subvitellinum. Structura microscopica quod in typus. Sporae 5.5–7.5 × 2.5–3.0 μm.

Holotype: **ISRAEL. UG**, Savsufa Forest, *Quercus calliprinos* forest, on oak stump, 11.02.2008, leg. D. Țura, det. D. Țura et I. Zmitrovich (HAI 0193).

Basidiocarps perennial, usually sessile with narrow base, 1–2.5 cm wide and 1.5–3.5 cm long; pilei flabelliform to irregular, regularly lobate, confluent both in basal and marginal parts. Abhymenial surface hirsute to hispid, grayish at the base and yellow-ochraceous at margin, regularly zonate, radiately plicate. Hymenial surface basically smooth but with radial concentric ridges along fruitbody growth axes, light-yellow to orange-grayish. Context thin, pale cream; in cross-section with a very thin cinnamomeous deposit between tomentum and context.

The microstructure is the same as in all other specimens of *S. hirsutum* studied; acanthohyphidia absent. Spores 5.5–7.5 × 2.5–3.0 μm.

Note. Such a specific lobulate and subfasciate habit has not been described for *Stereum hirsutum*, at least not in well-known monographs (Eriksson et al. 1984, Davydkina 1980, Chamuris 1988, Duhem 2007). Chamuris (1988), who noted possibly undulate or plicate fruitbody forms, did not mention deeply crenate lobules in his monograph.

All lobulate forms of this fungus were found in subxerophilic mountain oak forests (Upper Galilee, Golan Heights). In such extreme conditions, the fungal morphogenetic spectra are enriched by strange "marginal" forms. Some of these (e.g., *Byssomerulius corium* var. *halieensis* Zmitr. et al., *Peniophora*

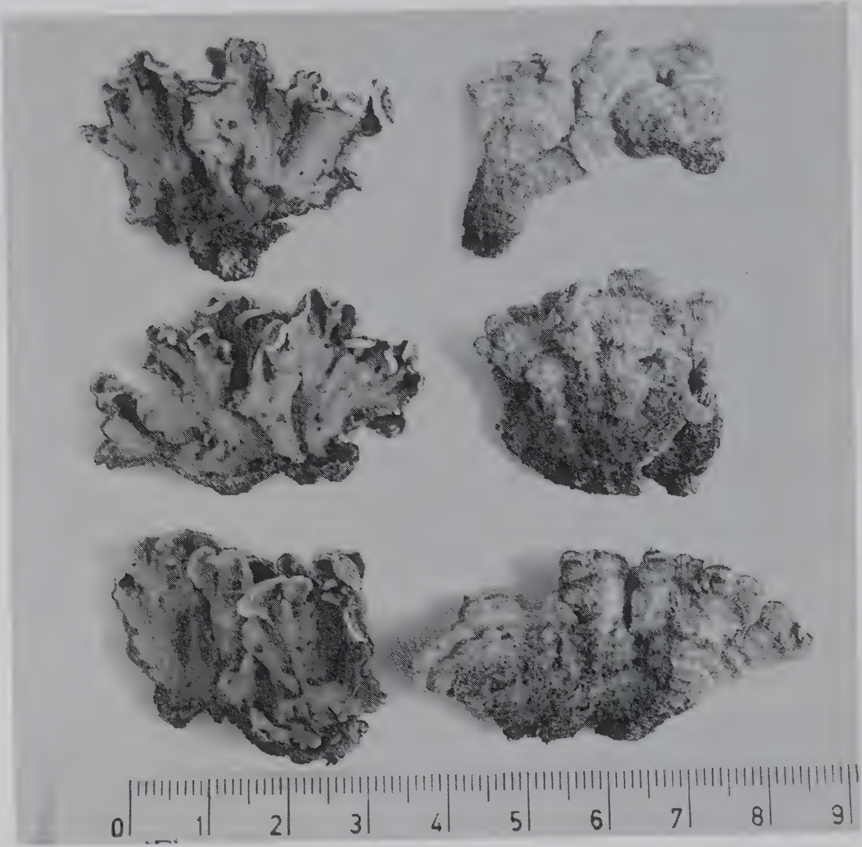

FIG. 11. *Stereum hirsutum* f. *lobulatum* fruitbodies variability.

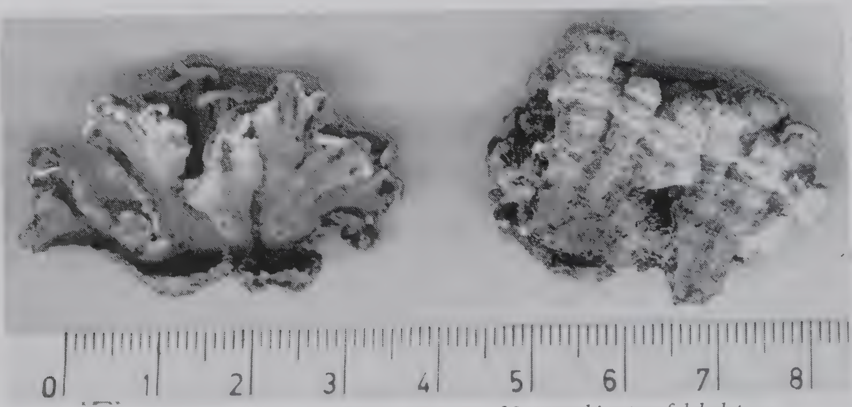

FIG. 12. A large-scale view of fruitbody cluster of *Stereum hirsutum* f. *lobulatum*.

quercina f. *merulioides* Ţura et al.) have been described earlier so as to highlight the variability range of these species (Zmitrovich et al. 2006, Ţura et al. 2007).

These formations are very important for an internal differentiation of the species because over time reproductive barriers may occur within such ecotypic subpopulations that may lead to eventual speciation.

Specimens examined: **ISRAEL. UG**, Mt. Meron National Park, on *Pinus*?, 27.12.2000, leg. S. Reshetnikov, det. S. P. Wasser (HAI 0115); ?, Harshad Harbaim, on branch of dead oak, 1.02.2001, leg. S. Reshetnikov, det. S. P. Wasser (HAI 0116); ?, Harshad Harbaim, on *Quercus* stump, 24.02.2001, leg. I. Tovbin, det. S.P. Wasser (HAI 0117); **UG**, Salsufer Forest, on *Q. calliprinos* wood, 19.11.2006, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0118); **UG**, Bar'am Forest, *Q. calliprinos* forest, on *Quercus* stump, 16.12.2006, leg. D. Ţura, det. D. Ţura, I. Zmitrovich et V. Malysheva (HAI 0119); **GH**, Massada Forest, *Q. calliprinos* forest, on broadleaf wood, 26.11.2006, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0120); **LG**, Oshaya Forest, mixed *Pinus* and *Quercus* wood, on *Quercus* stump, 16.12.2006, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0121); **UG**, Nahal Keziv, mixed hardwood forest, on *Quercus* stand, 20.12.2006, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0122); **MC**, Muhraqua, *Q. calliprinos* forest, on *Quercus* stump, 24.12.2006, D. Ţura, I. Zmitrovich et V. Malysheva (HAI 0123); **GH**, Qazrin, mixed forest, on *Cupressus* stump, 09.01.2007, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0124); **GH**, Massada Forest, *Q. calliprinos* forest, on broadleaf wood, 09.01.2007, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0125); **MC**, Mt. Carmel Natural Park, mixed *Quercus* and *Pinus* forest, on *Quercus* branches, 12.01.2007, leg. S. Zohar, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0126); **UG**, Even Menahem, *Quercus* forest, on hardwood stump, 22.01.2007, leg. Y. Ur, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0127); **UG**, Hanita Forest, *Q. calliprinos* forest, on branches of *Q. calliprinos*, 31.01.2007, leg. Y. Ur, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0128); **LG**, Lavi Forest, mixed *Pinus* and *Quercus* forest, on oak twig, 04.02.2007, leg. Y. Ur, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0129); **UG**, Kiryat Shmona, *Eucalyptus* wood, on hardwood twigs, 11.02.2007, leg. Y. Ur, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0130); **SA**, Reihan Forest, mixed *Pinus* and *Quercus* wood, on hardwood twigs, 19.02.2007, leg. Y. Ur, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0131); **UG**, Kiryat Shmona, *Eucalyptus* wood, on hardwood stump, 20.02.2007, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0132); **UG**, Banias Park, mixed broadleaf trees, 20.02.2007, leg. Yair Ur, det. D. Ţura, I. Zmitrovich et V. Malysheva (HAI 0133); **UG**, Sde Eliezer, on *Eucalyptus* tree, 21.02.2007, leg. Y. Ur, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0134); **GH**, Massada Forest, *Q. calliprinos* forest, on oak stump, 07.03.2007, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0135); **UG**, Kiryat Shmona, *Eucalyptus* wood, on hardwood stump, 07.03.2007, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0136); **LG**, near Kabul, mixed hardwood forest, on *Eucalyptus* stump, 07.03.2007, leg. D. Ţura, det. D. Ţura, I. Zmitrovich et V. Malysheva (HAI 0137); **UG**, Mt. Meron, *Q. calliprinos* forest, on *Quercus* stump, 09.03.2007, leg. & det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0138); **UG**, Bar'am Forest, *Q. calliprinos* forest, on *Quercus* stump, 09.03.2007, leg. D. Ţura, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0139); **SP**, Ben Shemen Forest, mixed broadleaf trees, on ?, 16.03.2007, leg. Y. Ur, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0140); **UG**, Canyon Agam, *Quercus* forest, on *Quercus* stump, 17.03.2007, leg. Zohar S., det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0141); **GH**, Hanita Forest, *Q. calliprinos* forest, on branches of *Q. calliprinos*, 20.03.2007, leg. Y. Ur, det. D. Ţura, I. Zmitrovich & V. Malysheva (HAI 0142).

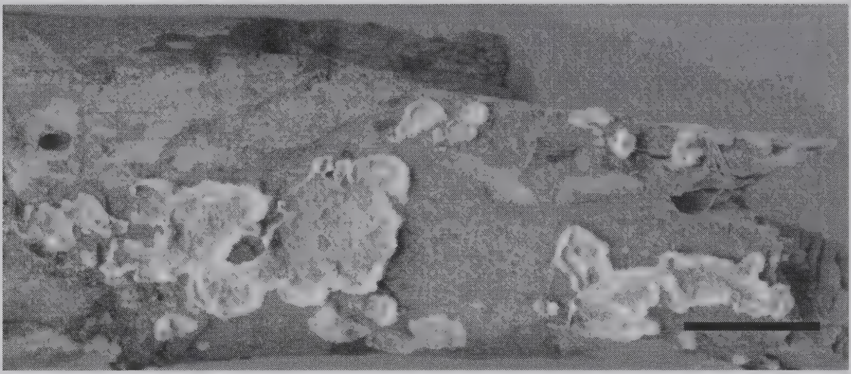

Fig. 13. Dry fruitbodies of *Stereum sanguinolentum* on fallen pine wood.
Scale bar = 1 cm.

Stereum sanguinolentum (Alb. & Schwein.) Fr., Epicr. Syst. Mycol.: 549, 1838.
Figs. 13–15

≡ *Thelephora sanguinolenta* Alb. & Schwein., Consp. Fung. Lusat.: 274, 1805.

Basidiocarps annual, hard-coriaceous, resupinate, totally prostrate with free margins 3–4 mm wide, in appearance as several small, hardly separable, round-ovoid patches scattered on wood substratum, confluent and expanding up to 5 cm in length. Abhymenial surface strigose-tomentose, easily zonate, white-cream, with thin inflexed margin. Hymenial surface even to tuberculate, grayish-brown with violaceous tinge mostly in the central part of

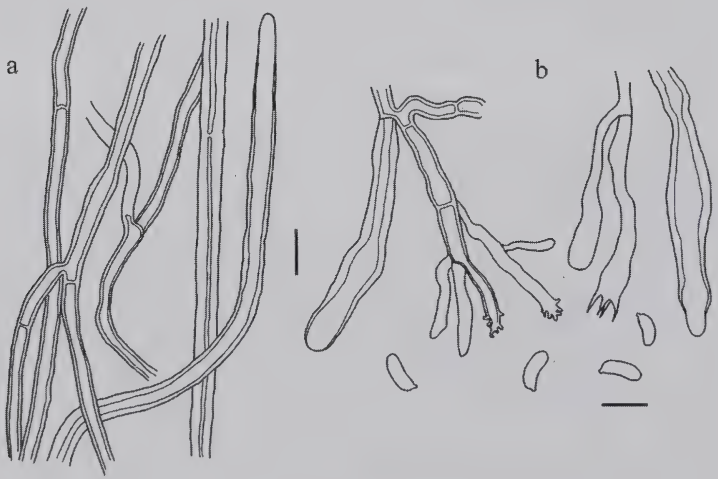

Fig. 14. Microscopic structures of *Stereum sanguinolentum*:
a – hyphae; b – hymenial fragment showing slender thick-walled pseudocystidia among acanthohyphidia, basidia, and basidiospores. Scale bar = 10 µm.

the patches, color becoming gradually lighter towards the undulating margin. Hymenophore of dried specimens bleeding when bruised. Context thin, light-colored, 0.5–1 mm thick, in cross-section a reddish-brown thin deposit is seen (barely observable without magnifier).

Hyphal system pseudodimitic. Generative hyphae simple-septate, hyaline, thin- to thick-walled, 3–4 µm diam, branched; pseudoskeletal hyphae thick-walled, rarely septate, 3–6 µm diam. Conducting hyphae of the same dimensions, but without septa and with oil-rich brown contents, occur in subhymenial and medullar tissues. Cystidia not seen but cystidia-like hyphal ends (pseudocystidia) present. Pseudocystidia cylindrical to subcylindrical, some with an inflated middle part up to 13 µm in diam., and narrow base; with basal walls 1.5–2 µm thick and brownish oily contents. Acanthohyphidia abundant, cylindrical, tapering towards apex, thin-walled, 20–30 × 3–4 µm in diam. Basidia cylindrical to narrowly clavate, 25–55 × 3–10 µm, 4-spored, without a basal clamp. Basidiospores ellipsoid to cylindrical, hyaline, smooth, thin-walled, (6–)7–10(–10.5) × (2–) 2.5–3(–3.5) µm, amyloid.

The species was found inhabiting pine wood in North of Israel (Fig. 15).

General distribution and habitat. Being associated with a white rot, *Stereum sanguinolentum* is a very affective and fast colonizer of newly dead or wounded conifer sapwood, probably the most important fungus involved in "wound rot of spruce" (Schmidt 2006, Calderoni et al. 2003). Many authors reported this species as parasitized by jelly fungus *Tremella encephala* Pers. According to our knowledge, the general distribution of *Stereum sanguinolentum* includes: Europe (Austria, Czech Republic, Denmark, Finland, France, Georgia, Germany, Iceland, the Netherlands, Norway, Portugal, Romania, Russia, Slovenia, Spain, Sweden, UK, Ukraine); Middle East (Israel); East Asia (Japan, Mongolia, South Korea); North America (Canada, USA); Other (Faeroe Islands).

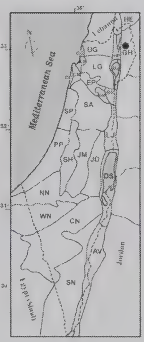

Fig. 15. Distribution of *Stereum sanguinolentum* in Israel.

Note. A notable difference distinguishing *S. sanguinolentum* from other similar species in the field is its coniferous substrate. Due to its red staining reaction when bruised, *S. sanguinolentum* might be confused with *S. rugosum*, *S. gausapatum*, and representatives of the *S. hirsutum*-complex. Diagnostic differences are: substratum, spore size, and presence of colored conducting hyphae. Jülich & Stalpers (1980) reports that although acanthohyphidia are mentioned in descriptions of American specimens, they are never reported for European material. The studied Israeli material is characterized by numerous acanthohyphidia.

Specimen examined: **ISRAEL. GH**, near Mt. Baron, *Pinus* forest, on pine fallen wood, 26.11.2006, leğ. D. Ţura, det. D. Ţura, I. Zmitrovich et V. Malysheva (HAI 0143).

Stereum subpileatum Berk. & M.A. Curtis, Hook. J. Bot. Kew Gard. Misc. 1: 238, 1849. Fig. 16

≡ *Xylobolus subpileatus* (Berk. & M.A. Curtis) Boidin, Rev. Mycol. 23: 341, 1958.

"Sporophore effused-reflexed, attached by the umbos, small, 1–1.5 cm long and up to 1.5 mm thick; pileus tomentose, grayish-orange to light brown or brown, somewhat zonate; margin brownish; hymenial surface light orange, smooth or somewhat pubescent. Context pale-orange. Hyphal system trimitic; skeletal hyphae thick-walled, 4–7 µm wide. Cystidia cylindric, thick-walled, encrusted, 5–7 µm wide. Basidia 20–40 × 3–5 µm, with 4 sterigmata; spores cylindric, 4–4.5 × 2–2.5 µm, hyaline, smooth" (Binyamini 1982).

The hyphal system of this species can be characterized as pseudodimitic to subdimitic (pseudoskeletal hyphae in older parts lose their plasmatic contents). Some sclerified elements are actually branched similar to "trimitic" polypore elements, a condition also observed in other *Stereum* species.

General distribution and habitat. Associated with white pocket rot, *Stereum subpileatum* occurs on living hardwood substrata, mainly oak. Its general distribution includes Europe (Austria, Macedonia, Russia, Spain); Middle East (Israel); East Asia (China, Japan, Nepal); North America (Canada, Cuba, Mexico, USA); South America (Colombia, Costa-Rica, Venezuela).

Note. According to Binyamini (1982), this species was found in Israel only once, in Samaria (Fig. 16), and differs from other Israeli *Stereum* species by widely effused, hard, perennial fruitbodies with cylindrical encrusted cystidia, and by the hard cover of small pilei (see also Chamuris 1988, Jülich & Stalpers 1980). Microscopically, *Stereum subpileatum* is highly similar to *S. frustulatum* (Pers.) Fr. (both considered conspecific by Welden, 1971). In many handbooks the two species have been treated as separate species belonging to the genus *Xylobolus*. However, we prefer another solution (see Introduction).

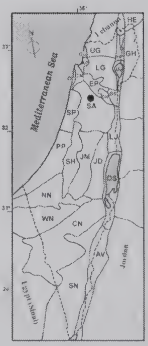

Fig. 16. Distribution of *Stereum subpileatum* in Israel.

Key to Israeli species of *Stereum*

1a. Acanthohyphidia absent 2

1b. Acanthohyphidia present 3

2a. Basidioles cylindrical. Pseudocystidia basal walls equal/less than 1.5 μm thick. Abhymenial surface condensed, subtomentose to nude. Hymenium bleeding when bruised, with crysescent conducting hyphae) .... ***S. gausapatum***

2b. Basidioles acuminate-cylindrical. Pseudocystidia thick-walled, basal walls usually more than 2 μm thick. Abhymenial surface hirsute-tomentose. Hymenium when injured, in basidiocarps with active growth, sometimes staining yellow-orange-red, but without conducting hyphae .... ***S. hirsutum***

3a. Basidiocarps annual, tough-coriaceous, not deeply cracking. Hymenium bleeding when injured, with abundant conducting hyphae. Pseudocystidia basal walls 1.5–2 μm wide. Basidiospores (6–)7–10(–10.5) × 2.5–3(–3.5) μm .... ***S. sanguinolentum***

3b. Basidiocarps perennial, hard-corneous, with deeply cracked multistratose hymenium. Hymenium not bleeding when injured, without conducting hyphae. Basidiospores 4–4.5 × 2–2.5 μm .... ***S. subpileatum***

Acknowledgments

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A note on *Stiptophyllum erubescens*

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Abstract — Fresh basidiomata of *Stiptophyllum erubescens* were studied and its macro and microstructures, mainly basidia and basidiospores, were elucidated.

Key words — *Agaricomycetes*, *Polyporaceae*, taxonomy

Introduction

Stiptophyllum Ryvarden (*Polyporaceae*, *Basidiomycota*) was described in 1973 with *Daedalea erubescens* as type species. With its stipitate basidiomata, it was proposed as a satellite genus to *Gloeophyllum* P. Karst., which has sessile basidiomata. *Stiptophyllum* is macroscopically distinguished by stipitate basidiomata, a tomentose pileus and stipe, and a lamellate hymenial surface. Microscopically it is characterized by a trimitic hyphal system and cylindrical, hyaline, and non-amyloid basidiospores (Ryvarden 1973). The genus is monotypic, causes a brown rot, and is endemic to tropical South America.

Basidiospores and basidia are notoriously difficult to observe in old and/or dried basidiomata since they apparently collapse very rapidly. The present study, carried out with fresh material, made it possible to elucidate these structures more accurate than earlier ones (Fidaldo 1959, Fidalgo 1968, Ryvarden 1973, Singer 1975, Wright & Deschamps 1977).

Materials and methods

Basidiomata of *S. erubescens* were collected during a recent field survey in the municipality of Mondaí (27°06”16’S and 53°24”07’W) in Linha Uruguai and Linha Sanga Forte, in the extreme west of the State of Santa Catarina in southern Brazil. The area was originally covered by Deciduous Seasonal Forest, and the samples for this study were collected in remnants of this original vegetational type (Ruschel et al. 2003). Macro- and microscopical data of the specimens were obtained following the traditional methodology (Singer 1975, Ryvarden 1991), and the colors were determined according to Munsell (1975). The examined specimens are preserved in Herbarium FLOR (Holmgren & Holmgren 1998).

Taxonomy

Stiptophyllum erubescens (Berk.) Ryvarden, Norweg. J. Bot. 20: 4. 1973. FIGS 1–2

≡*Daedalea erubescens* Berk., Ann. Nat. Hist. 4: 292. 1840.
≡*Lenzites erubescens* (Berk.) Sacc., Syll. Fung. (Abellini) 5: 645. 1887.
≡*Cellularia erubescens* (Berk.) Kuntze, Revis. gen. pl. (Leipzig) 3(2): 452. 1898.
≡*Xerotus erubescens* (Berk.) Singer, Los Angeles County Mus. Contr. Sci. 24: 6. 1958.
≡*Xerotinus erubescens* (Berk.) Singer, Sydowia 15: 83. 1962 ['1961'].
≡*Gloeophyllum erubescens* (Berk.) Popoff, Mycotaxon 87: 105. 2003.
=*Lenzites guilleminiana* Lév., Ann. Sci. Nat., Bot., sér. 3, 5: 122. 1846.
≡*Lentinus guilleminianus* (Lév.) Mont., Ann. Sci. Nat., Bot., sér. 3, 5: 364. 1846.
≡*Pocillaria guilleminiana* (Lév.) Kuntze, Revis. gen. pl. (Leipzig) 2: 866. 1891.
=*Lentinus schomburgkianus* Henn., Hedwigia 36: 205. 1897.
=*Lentinus frondosus* Henn., Hedwigia 36: 206. 1897.
=*Lentinus fuscoferrugineus* Speg., An. Mus. nac. Hist. nat. B. Aires 19: 226. 1909.

BASIDIOMATA annual, laterally or eccentrically stipitate, solitary or in groups, connected at the base of the stipes or sometimes in groups with entirely free stipes and laterally fused pilei. PILEUS rounded to almost infundibuliform or flabelliform, with a large variation in size, cartilaginous, flexible and somewhat humid when fresh, firm and light in weight when dry, up to about 15 × 12.5 × 1.5 cm; pileus surface trichodermoid, without cuticle, coriaceous when young becoming rigid and woody in time, finely subtomentose to glabrous, rough, concentrically zonate and sulcate, striate near to the margin, yellow (8/6-8/8, 7/6-7/8 10YR) to brownish yellow (6/6-6/8 10YR) and dark yellowish brown (3/6 10YR) when dry; margin irregular, acute, rigid, undulate or lobate, white (8/1 5Y) when fresh becoming pale brown (6/3 10YR) to dark brown (3/3 10YR) when dried. STIPE subwoody to woody, initially velutinous then scabrous and longitudinally sulcate, 1–6 × 1.5–4.5 cm, very pale brown (7/4 10YR) when fresh to dark yellowish brown when dried (4/4-3/4 10 YR), pseudo-sclerotium present at the base of the stipe, always wider than the rest of the stipe. HYMENOPHORE lamellate, subdaedaloid or irpiciform, lighter than the surface of the pileus, very pale brown (7/4 10YR) when fresh to light yellowish brown to brownish yellow (6/4-6/8 10YR) when dry, lamellae coriaceous to rigid, deeply decurrent, 6–12 per cm at the margin, edges initially entire then crenate, irregular, up to 5 cm in length and 0.9 cm deep, very pale brown when fresh (7/4 10YR) to brownish yellow (6/6 10YR), when dry become dark yellowish brown (4/6 10YR). CONTEXT corky, conspicuous, homogeneous, contrasting with the pileus surface, soft, almost tough when dry, 1–4 mm thick, brownish yellow (6/8 10YR) to dark yellowish brown (3/4 10YR).

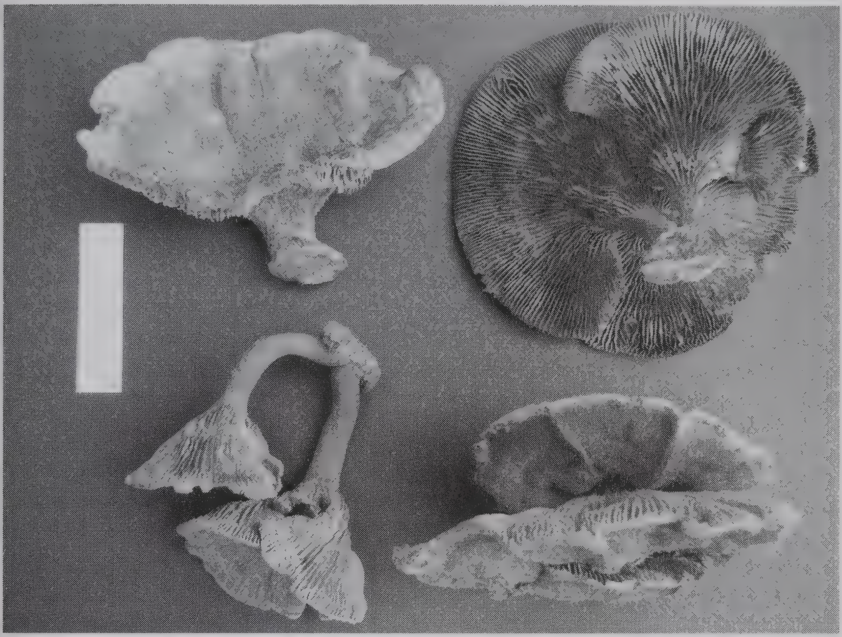

Figure 1 – General aspect of basidiomata: FLOR 32202, 32203, 32204 and 32206. Scale = 5cm.

Hyphal system - trimitic; in the trama generative hyphae hyaline, clamped, thin-walled to slightly thick-walled, 2–3(–4) µm in diam.; skeletal hyphae yellowish to brown, unbranched, non-septate, thick-walled to solid, tortuous, walls with many constrictions, sometimes with moniliform aspect, 3–7 µm in diam.; binding hyphae subhyaline to yellowish brown, very branched, 2–4 µm diam., thick-walled to subsolid. Hyphal system of the context similar to the trama, in stipe hyphae slightly dextrinoid, simple-septate. Basidia hyaline to slightly stained, clavate and tetrasporic, thin-walled and smooth, constricted or sometimes collapsed at the base, 35–40 × 5–6 µm; basidioles smaller than the basidia, 20–33 × 2–4 µm; Basidiospores cylindrical-ellipsoid, hyaline to slightly yellowish, thin-walled, 9–12 × 3–4(–5) µm, inamyloid and nondextrinoid.

Substrate – dicotyledonous dead wood.

Distribution – Neotropical; Bolivia, Colombia, Peru, Venezuela, Guiana, Argentina, Paraguay and Brazil: Acre, Rio Grande do Norte, Rio de Janeiro, Mato Grosso, Rio Grande do Sul, Amazonas, Pará, Goiás, Bahia, Paraíba, Paraná and Santa Catarina (Fidalgo 1968, Ryvarden 1973, Ryvarden 1991, Singer 1975, Wright & Deschamps 1977, Bononi 1992, Ryvarden & Iturriaga 2001, Popoff 2003, Gibertoni et al. 2004, Drechsler-Santos 2005, Campos-Santana & Loguercio-Leite 2008).

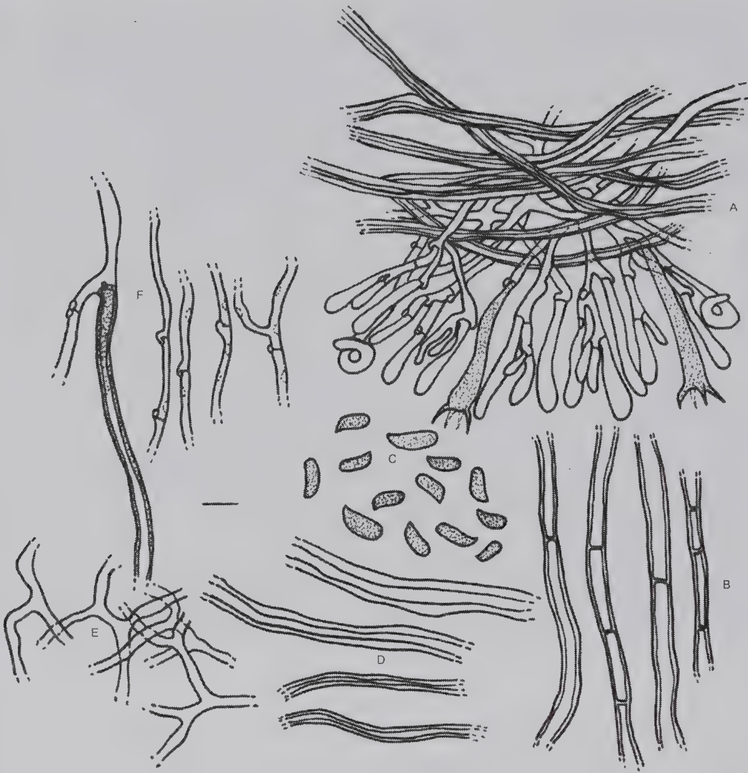

FIGURE 2 – A. Hymenium. B. Generative hyphae from stipe. C. Basidiospores. D. Skeletal hyphae from trama. E. Binding hyphae from trama. F. Generative hyphae. Scale =10 μm.

VOUCHER MATERIAL — **BRASIL, SANTA CATARINA: Mondaí** 15/IV/06 Linha Sanga Forte, Campos-Santana & Santana 71 (FLOR 32202), Linha Sanga Forte, Santana & Zanella 91 (FLOR 32203); 23/V/07 Linha Sanga Forte, Campos-Santana & Santana 236 (FLOR 32304), 256 (FLOR 32205) & 297 (FLOR 32206).

ADDITIONAL MATERIAL — **BRAZIL, Santa Catarina: Itapiranga** 15/IV/1985 Linha Becker, Scholz (FLOR 10108).

REMARKS. Specimens of *Stiptophyllum erubescens* are flexible and moist when fresh, firm and lighter in weight when dry. The subwoody to woody stipe is initially velutinous then scabrous and longitudinally sulcate and has a pseudosclerotium at the base. As noted by Wright & Deschamps (1977), specimens stain dark brown when touched with KOH. Skeletal hyphae in the stipe appear slightly dextrinoid and generative hyphae are simple-septate, both features cited for this species here for the first time. In previous cultural studies, Wright & Deschamps (1977) described brownish simple-septate hyphae that contrast with observations by Ryvarden (1973), "...binding hyphae hyaline, thick-walled to solid, some ending in the hymenium as solid cystidia...", which were not seen in our specimens. In some specimens (FLOR 32204; 32206) the basidiospores – generally considered important for classification of the *Agaricomycetes* (Ryvarden 2004) – were ellipsoid to cylindrical [9–12 × 3–4 (–5) µm], hyaline to slightly brown, thin-walled, inamyloid and nondextrinoid. Wright & Deschamps (1977), however, reported smaller basidiospores [6.6–8.2 (–9.6) × (1.8–)2.6–3.6 µm]. Neither Ryvarden (1973) nor Drechsler-Santos 2005) cite basidiospore size data, although Ryvarden (2004) reported that specimens collected during periods without active growing have few or no basidiospores. We also did not find basidiospores in some specimens (FLOR 32202, 32203 and 32205). Basidia sizes [35–40 × 5–6 µm] in our specimens are similar [20–52 × 4.1–6.5 µm] to those cited by Wright & Deschamps (1977) but are larger than those reported by Fidalgo (1968) [16.5–24 × (4–)4.5–7.5 µm].

The taxonomic position of *S. erubescens* is still subject to debate. Singer, who accepted it in *Xerotus* Fries, initially stressed the presence of stipe as the main difference separating it from *Gloeophyllum* (Singer 1975) but later added the hyphal system as also diagnostic (Singer 1986). Fidalgo (1968) and Wright & Deschamps (1977) both considered *S. erubescens* to have a dimitic hyphal system. As previously mentioned, Ryvarden (1973) based *Stipitophyllum* on the presence of a stipe and trimitic hyphal system. Recently, Popoff (2003) proposed a new combination – *Gloeophyllum erubescens*, placing the main emphasis on the brown rot decay. Most recently, Hibbett et al. (2007) proposed the order *Gloeophyllales* Thorn to accommodate all species in the *Gloeophyllum* clade (Binder et al. 2005), which includes species producing brown rot (*Gloeophyllum, Neolentinus, Veluticeps*) or stringy white rot (*Boreostereum, Donkioporia*). No molecular studies have yet been performed on *S. erubescens* (Kim & Jung 2000, Binder et al. 2005) but future sequence analyses may help clarify the taxonomic situation of this species and determine whether it belongs to an independent genus or is part of *Gloeophyllum.*

Acknowledgments

We are grateful to Leif Ryvarden (Norway), Aristóteles Góes-Neto (Brazil), and Shaun Pennycook (New Zealand) for their help in the correction and improvement of the present paper. This work is part of M.Sc. thesis in Biologia Vegetal (Universidade Federal de Santa Catarina, Brazil) of the first author.

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Taxonomic studies on *Ustilaginomycetes* - 28

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Abstract—The problem of generic delimitation of *Tranzscheliella* and *Tranzscheliella*-like smut fungi is discussed. New species described are: *Sporisorium mandlaicum, S. shivasiorum, Thecaphora arnicae, Tranzscheliella poae, Ustilago milii-vernalis, U. sclerachnes.* New name proposed: *Sporisorium ciccaronei.* New combinations proposed: *Bauerago tinantiae, Entyloma arnaudianum, Gjaerumia eremuri, G. muscari, Sporisorium stiparum, Thecaphora solidaginis, Tolyposporium isolepidis, Tranzscheliella distichlidis, Tr. iranica, Tr. stipae-barbatae, Urocystis bulbinellae, Ur. simplex.* Taxa placed in synonymy are: *Entyloma crepidis-tectorum* (= *E. zacintha*), *E. lavrovianum* (= *E. hieracii*), *Urocystis radicicola* (= *Ur. rechingeri*), *Ustilago duriusculae* (= *U. striiformis*) and *Ustilago moehringiae* (= *Microbotryum duriaeanum*). Excluded from the smut fungi is: *Melanotaenium spermacoces.* Lectotypes are designated for *Entyloma lobeliae* and *Sorosporium solidaginis.* Keys are given to the species of *Gjaerumia,* of *Melanotaenium,* and of *Tranzscheliella,* to the smut fungi of *Chionachne* and related genera, of *Elionurus,* of *Eulalia* and *Eulaliopsis,* and of *Sehima,* to the *Urocystis* species of *Anemone* and *Anemonella,* and to the genera of smut fungi.

Key word—taxonomy

Tranzscheliella and *Tranzscheliella*-like smut fungi

Lavrov (1936:29) described a new genus and species, *Tranzscheliella otophora* Lavrov (= *T. williamsii*), on the basis of two, small cells attached at opposite sides of the spores of a smut fungus collected on the stems of *Stipa pennata* from Turkmeniya. Only half a century later, with help of a scanning electron microscope (SEM), it was demonstrated (Vánky 1985:256, Fig. 240; 1987:121; 1994:446, Figs. 466a, b, c) that these two small cells were actually the oppositely situated opercula or lids, which are circularly broken parts of the thick exospore, attached to the spore on a relatively short part of their circumference. The opercula are closed when the spores are dried, and opened when the spores are rehydrated. Presence of opercula alone did not seem to be a sufficiently strong morphological character for recognising a separate genus. Together with the morphology of sori, the spores as well as spore germination, the genus

Tranzscheliella was recognised as a well circumscribed group of smut fungi, all on members of *Poaceae* (Vánky 2002:162). Because of the morphological similarities between *Ustilago hypodytes* and *Tranzscheliella williamsii* (except for the opercula), *U. hypodytes* was transferred into this genus as 1. ***T. hypodytes*** (Schltdl.) Vánky & McKenzie (Vánky & McKenzie 2002:156; type on *Elymus arenarius* L., Germany). Several smut fungi, with similar morphology, i.e. possessing external, naked, powdery sori on the surface of the stems, rarely also on floral axes of *Poaceae*, and solitary, brown, small-sized spores, were also transferred into the genus *Tranzscheliella* (Vánky 2003:2–4, 2004:109), or described as new species. These are: 2. ***T. amplexa*** (Syd.) Vánky (Vánky 2004:109; type on *Diplachne fusca* (L.) P. Beauv. ex Roem. & Schult., Egypt), 3. ***T. austrostipae*** R.G. Shivas & Vánky (Shivas & Vánky 2007:9; type on *Austrostipa verticillata* (Nees ex Spreng.) S.W.L. Jacobs & J. Everett, Australia), 4. ***T. comburens*** (F. Ludw.) Vánky & McKenzie (Vánky & McKenzie 2002:155; type on *Stipa* sp., = misnamed *Danthonia* sp., Australia), 5. ***T. halophila*** (Speg.) Vánky (Vánky 2003:2; type on *Distichlis scoparia* (Kunth) Arechav., Argentina), 6. ***T. halophiloides*** (G.W. Fisch.) Vánky (Vánky 2003:2; type on *Distichlis stricta* (Torr.) Rydb., USA), 7. ***T. jacksonii*** (Zundel & Dunlap) Vánky (Vánky 2003:3; type on *Stipa lettermanii* Vasey, USA), 8. ***T. laevispora*** Vánky (Vánky 2004:82; type on *Sporobolus agrostoides* Chiov., Kenya), 9. ***T. macrochloae*** (Pat.) Vánky (Vánky 2003:3; type on *Macrochloa tenacissima* (L.) Kunth = *Stipa tenacissima* L., Tunisia), 10. ***T. minima*** (Arthur) Vánky (Vánky 2003:3; type on *Oryzopsis cuspidata* Benth. ex Vasey, USA), 11. ***T. serena*** (Syd.) Vánky (Vánky 2004:109; type on *Diplachne fusca*, Australia), 12. ***T. sparti*** (Massenot) Vánky (Vánky 2003:4; type on *Lygeum spartum* L., Tunisia), 13. ***T. ventanensis*** (Hirschh.) Vánky (Vánky 2003:4; type on *Stipa* sp., Argentina), and 14. ***T. williamsii*** (Griffiths) Dingley & Versluys (Dingley & Versluys 1977:477; type on *Stipa richardsonii* Link, USA).

In 2002, mycologists from University of Tübingen and I started a detailed study of the genus *Tranzscheliella*, including molecular analyses. An important taxonomic conclusion from the interrupted study was that not all morphologically *Tranzscheliella*-like smut fungi belong to this genus. This became evident by the analysis of *T. comburens*, which actually belongs to the genus *Ustilago*, as originally described (M. Stoll & D. Begerow, pers. comm.). Further *Tranzscheliella*-like smuts, *U. triodiae* Vánky (comp. Stoll et al. 2005) and *U. lituana* R.G. Shivas et al., are also true *Ustilago* species (comp. Shivas et al. 2006:365).

Recently, Begerow et al. (2007:914) demonstrated by molecular phylogenetic analyses that "*Macalpinomyces* and *Tranzscheliella,* which both occur on *Poaceae*, are not members of the clade representing *Ustilaginaceae*." The isolated position of *Tranzscheliella* outside the large *Ustilago-Sporisorium* complex may justify its recognition as a good genus. In the absence of reliable morphological characters for the genus *Tranzscheliella,* molecular phylogenetic analyses may be necessary to resolve species delimitation. It appears that *Tranzscheliella hypodytes, T. minima, T. sparti* and *T. williamsii* are true species (M. Stoll & D. Begerow, pers. comm.). In the absence of molecular phylogenetic studies, placement of some smuts into *Tranzscheliella* or *Ustilago* is uncertain and can be considered only provisional. Similarly, uncertain are several of the synonyms and the host plant genera of *T. hypodytes* s.lat., enumerated in Vánky & McKenzie (2002:156–158).

Molecular phylogenetic analysis of *Tranzscheliella* "*hypodytes*" on *Poa cita* from New Zealand showed an isolated position from all other analysed *Tranzscheliella* species (M. Stoll & D. Begerow, pers. comm.). This means that the smut on *Poa cita* represents a separate species. If all *T. hypodytes*-like smuts on various *Poa* species were conspecific, the name *Ustilago custanaica* Lavrov (type on *Poa pratensis*, Siberia, deposited where?) could be applied to them. Two of the collections on *Poa* species, namely *Poa poiformis* from Australia (HUV 17630) and *Poa nevadensis* from the USA (HUV 10169), have spores that are morphologically identical with those of *T. hypodytes* (spores 4–6.5 µm long, with polar caps), whereas those of the analysed *Poa cita* have smaller spores (3.5–5.5 µm long, only with polar thickenings). The spores in the original description of *Ustilago custanaica* are 3.5–7 µm long, and it has to be considered a synonym of *T. hypodytes.* The smut on *Poa cita* represents a new species.

Tranzscheliella poae Vánky, **sp. nov.**

MycoBank: 511638

Typus in matrice Poa cita, *New Zealand, South Island, Central Otago, 20 km S oppid. Alexandra, Old Man Range, Symes Road, 45°20'17" S, 169°17'04" E, alt. 750 m.s.m., 6.II.1998, leg. E.H.C. McKenzie, C. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 18620, isotypi in PDD 69200, et in Vánky, Ust. exs. no. 1049 (ut* Ustilago hypodytes*). Paratypus in matrice* Poa cita, *New Zealand, South Island, Mid-Canterbury, Christchurch, Port Hills, Victoria Park, 13.XII.1981, leg. G.C. Kirby, PDD 41990, isoparatypus in HUV 16473.*

Tranzscheliella poae *differt a specie* T. hypodytes *(Schltdl.) Vánky et McKenzie, Smut Fungi of New Zealand:156, 2002. (*Caeoma hypodytes *Schltdl., Fl. Berol., Pars 2. Cryptogamia:129, 1824) sporis minoribus (3–4,5 × 3,5–5,5 µm), capsulis polaribus minoribus, incrassationibus tantum laterum deplanatorum, et imprimis characteribus biologicis molecularibus distinctis. Sporae speciei* T. hypodytes *3,5–5,5 × 4–6(–7) µm, plerumque pileo polari hyalino minuto instructae.*

Sori (Fig. 1) surrounding the distal internodes of sterile shoots, more or less hidden by leaf sheaths, spore mass naked, dark brown, powdery. Spores (Figs. 4, 5) globose, subglobose, slightly flattened, 3–4.5 × 3.5–5.5 µm, olivaceous-brown; wall even, c. 0.5 µm thick, in LM apparently smooth to very finely punctate, often with two flat, hyaline, finely verruculose thickenings, i.e. weakly

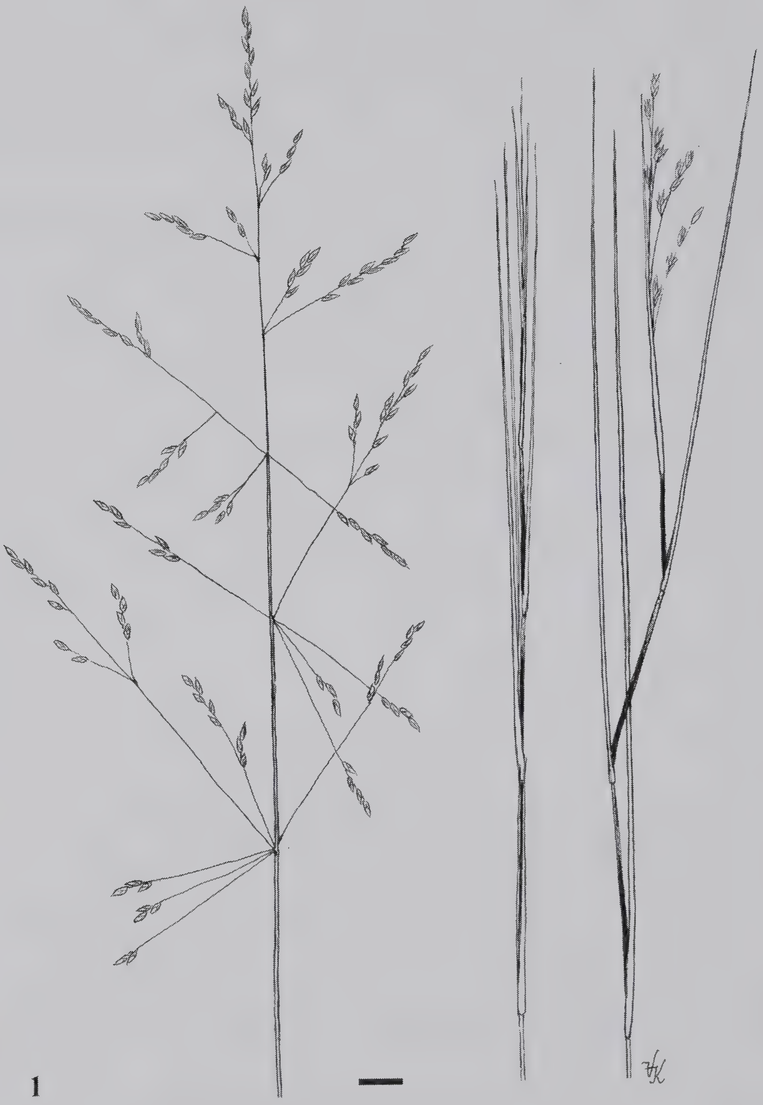


Fig. 1. Sori of *Tranzscheliella poae* on the stem of *Poa cita* (type). Habit, and to the left a healthy inflorescence. Bar = 1 cm.

developed polar caps on the flattened sides, in SEM finely, rather densely provided with warts of variable sizes due to fusion.

On *Poaceae: Poa cita* Edgar (*P. caespitosa* Spreng.); New Zealand.

Tranzscheliella poae differs from *T. hypodytes* in having smaller spores, weakly developed polar caps, and especially by different molecular biological characters in *T. poae* (unpublished data). In the literature, several *Poa* species are given as host plants of "*Ustilago*" *hypodytes,* including *P. nevadensis* Vasey, *P. poiformis* (Labill.) Druce, *P. pratensis* L., *P. ampla* Merr., *P. canbyi* (Scribn.) Howell, *P. juncifolia* Scribn., *P. palustris* L., and *P. scabrella* (Thurb.) Benth. (*P. buckleyana* Nash), mostly from N America but also from E Asia. Some of these hosts could harbour *T. poae.*

Because of the close resemblance of the character complex of the sori and spores to the type species *Tranzscheliella hypodytes*, and also using host plant criteria, three further smut fungi are considered best placed into the genus *Tranzscheliella*. These are:

Tranzscheliella distichlidis (McAlpine) Vánky, **comb. nov.**

MycoBank: 511639

Basionym: *Cintractia distichlidis* McAlpine, The smuts of Australia:169, 1910, as '*distichlydis*'. — *Ustilago distichlidis* (McAlpine) Cif., Ann. Mycol. 26:32, 1928, as '*distichlydis*'. — Lectotype on *Distichlis maritima* (= *D. distichophylla*), Australia, (design. by Vánky 2001:321) Victoria, Port Phillip, X.1891, C. French jr., MEL 1055118!; isolectotypes HUV 19156!, VPRI 2923. Paratype on *D. maritima,* Australia, Victoria, Sandringham, 5.IX.1905, D. McAlpine, VPRI 2924.

Sori surrounding the distal internodes of sterile shoots, more or less hidden by the leaf sheaths, at first covered by a thin, greyish peridium that gradually flakes away, exposing the dark brown, powdery mass of spores. Spores globose, subglobose, ellipsoidal, 4.5–6 × 5–6.5 µm, reddish-brown; wall even, c. 0.5 µm thick, polar caps absent, in LM smooth, in SEM finely, sparsely to moderately densely verruculose.

On *Poaceae: Distichlis distichophylla* (Labill.) Fassett (*D. maritima* Raf.; *D. spicata* auct. non (L.) Greene); Australia.

Tranzscheliella iranica (Syd.) Vánky, **comb. nov.**

MycoBank: 511640

Basionym: *Ustilago iranica* Syd., Ann. Mycol. 37:199, 1939. — Type on *Stipa tenerrima,* North Iran, Elburs Mountains, Mt. Kuh-e-Nemar, near Panshand, 3.VI.1937, D.E. Gauba 1233. Holotype B, isotype HUV 14817!

Sori destroying the whole inflorescence, partly enclosed by the uppermost leaf sheaths, up to 7 cm long, with black or blackish-brown, powdery spore mass, peridium absent. Spores subglobose, broadly ellipsoidal or rounded subpolyhedrally slightly irregular, 4–7 × 5–8 µm, yellowish- to olivaceous-brown; wall 0.5–1.5 µm thick, from apparently smooth to finely, densely verrucose, spore profile smooth to finely wavy, no polar caps, in SEM with rounded, low warts fusing into irregular groups or short, irregular rows.

On *Poaceae: Stipa tenerrima* Bornm. & Gauba; Asia (Iran). Known only from the type locality.

Tranzscheliella iranica is close to the South American *T. ventanensis,* in which the spores are pronouncedly verrucose and the sori surround the uppermost internodes and aborted inflorescence. The report of *T. iranica* from China (Guo 2000:73) may in fact represent a *Sporisorium* sp.(?) or result of insect infestation (L. Guo, pers. comm.).

Tranzscheliella stipae-barbatae (Maire) Vánky, **comb. nov.**

MycoBank: 511641

Basionym: *Ustilago stipae-barbatae* Maire, Bull. Soc. Hist. Nat. Afrique N. 8:139, 1917. — *Cintractia stipae-barbatae* (Maire) Maire, in Maire & Werner, Mém. Soc. Sci. Nat. Maroc. 45:44, 1937. — Lectotype on *Stipa* (design. by Vánky 1985:256) *barbata,* Morocco, Taourirt, 4.VI.1916, L. Ducellier, Herb. Maire 4226, MPU! Paratype on *Stipa gigantea,* Algeria, Miliana, near the top of Zaccar Rharbi, 12.VII.1917, R. Maire, Herb. Maire 4810, MPU!

Sori in the whole inflorescence, enclosed by the uppermost leaf sheath, spore mass naked, dark brown, powdery. Spores globose, subglobose, ellipsoidal to slightly irregular, slightly flattened (4–5.5 µm wide), in plane view 5–6.5 × 5.5–7 (–8) µm, dark brown, lacking polar caps; wall 0.8–1 µm thick, thicker on the flattened sides where, after boiling, indistinct opercula may appear, surface in LM smooth, in SEM, at high magnification, finely, densely verruculose.

On *Poaceae: Stipa barbata* Desf., *S. gigantea* Link (*Macrochloa arenaria* (Brot.) Kunth), *S. pennata* L.; N Africa, Asia.

Key to the species of *Tranzscheliella*

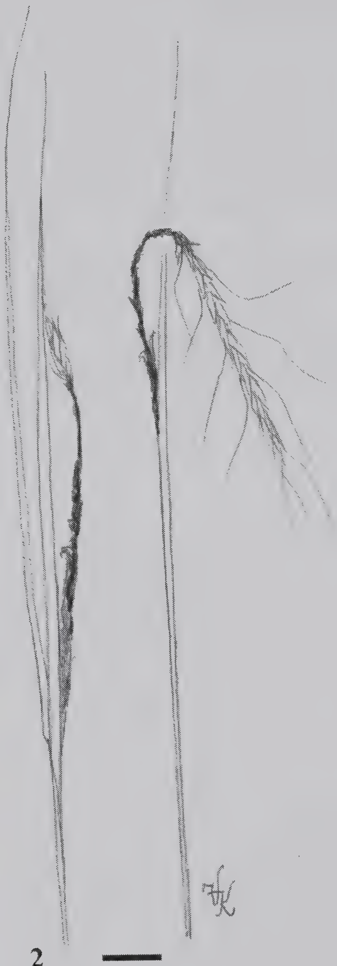
1. Spores in LM with 2, large, bipolar appendages, in SEM operculate. . ***T. williamsii***
– Spores not so 2
2. Spores in LM sparsely, evidently verrucose, in SEM with small tubercles . . . . ***T. halophiloides***
– Spores not so 3
3. Spores hemiglobose or cup-shaped 4
– Spores globose, subglobose, ellipsoidal or slightly irregular. 5
4. Spores 6–8(–9) µm long, in SEM very finely, densely verruculose. On *Distichlis* . . . . ***T. halophila***
– Spores 4.5–6.5 µm long, in SEM smooth. On *Sporobolus* . . . . ***T. laevispora***
5. Spores 8–13.5(–16) µm long . . . . ***T. jacksonii***
– Spores smaller 6

6. Spores 7–10.5 µm long 7
– Spores smaller 8
7. Peridium present; spores in SEM sparsely verrucose. On *Diplachne* .... *T. serena*
– Peridium absent; spores in SEM densely verruculose. On *Austrostipa* .... *T. austrostipae*
8. Sori in the inflorescence 9
– Sori on the culms 12
9. Well-developed peridium present .... *T. macrochloae*
– Peridium absent 10
10. Spore wall 0.5-1.5 µm thick, in SEM with rounded, low warts; fusing into short, irregular rows or groups. On *Stipa* .... *T. iranica*
– Spore wall up to 1 µm thick, in SEM finely, densely verruculose or indistinctly warty 11
11. Spores 6-8 µm long, in SEM finely, densely verruculose. On *Lygeum* .... *T. sparti*
– Spores 5.5-7(-8) µm long, in SEM indistinctly warty. On *Stipa* *T. stipae-barbatae*
12(8). Spores 4–5(–6) µm long 13
– Spores larger 14
13. Well developed peridium present .... *T. minima*
– Peridium absent .... *T. poae*
14. Spores 5.5–8(–9) µm long; warts in SEM confluent into irregular groups; sori on the stems and in the inflorescence .... *T. ventanensis*
– Spores smaller; warts not confluent into groups; sori on the stems 15
15. A thin peridium present; spores 6–7(–7.5) µm long; polar caps absent .... *T. amplexa*
– Peridium absent; spores 4–6(–7) µm long; small polar caps often present .... *T. hypodytes*

New species

A new *Sporisorium* species on *Sehima nervosum* (*Poaceae*)

Sehima Forssk., a genus of five species in the Old World tropics, belongs to the subfamily *Panicoideae*, tribe *Andropogoneae*, subtribe *Ischaeminae*. It has been regarded as a segregate from *Ischaemum* (Clayton & Renvoize 1986:348). On species of *Sehima* seven smut fungi are known: 1. ***Jamesdicksonia dactylidis*** (Pass.) R. Bauer et al. (type on *Dactylis glomerata* L., Italy), 2. ***Sporisorium nervosum*** Vánky et al. (type on *Sehima nervosum* (Rottler) Stapf, Australia), 3. ***S. queenslandicum*** Vánky et al. (type on *Sehima nervosum*, Australia), 4. ***S. sehimae*** (M.S. Patil) Vánky (type on *Sehima nervosum*, India), 5. ***S. sehimicola*** Vánky (type on *Sehima ischaemoides* Forssk., Zimbabwe), 6. ***S. sulcati*** (M.S. Patil) Vánky (type on *Sehima sulcatum* (Hack.) A. Camus, India), and 7. ***Tilletia sehimae*** A.R. Patil et al. (type on *Sehima nervosum*, India). A new species, collected recently in India is:



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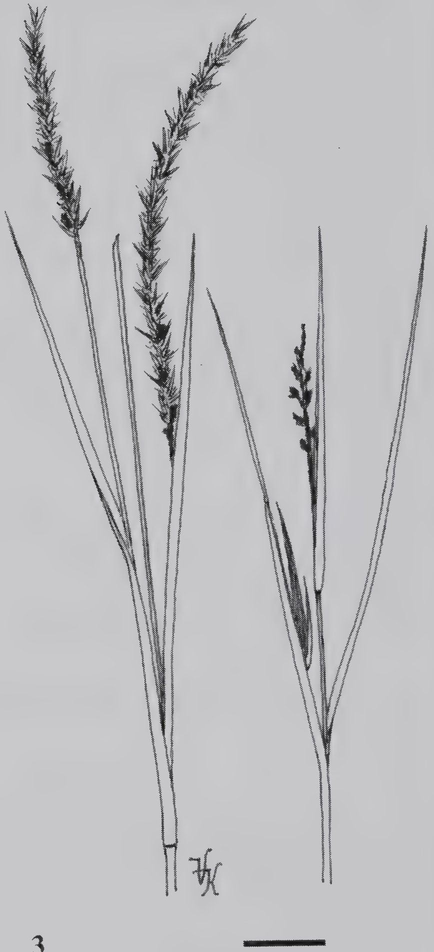

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Fig. 2. Sori of *Sporisorium mandlaicum* in the inflorescence of *Sehima nervosum* (type). Habit. Bar = 1 cm.

Fig. 3. Sori of *Sporisorium ciccaronei* on *Elionurus muticus* (type). Habit, and enlarged a healthy spikelet, two infected spikelets and an infected inflorescence.
Bars = 1 cm for habit, and 2 mm for detail drawings.

Sporisorium mandlaicum Vánky & N.D. Sharma, **sp. nov.**

MycoBank: 511642

> *Typus in matrice* Sehima nervosum, *India, Madhya Pradesh, Mandla, Kanha National Park border, 1 km ab Turia gate, 22°07' N, 80°26' E, alt. cca. 700 m.s.m., 7.X.2006, leg. N.D. Sharma. Holotypus in Herbario Ustil. Vánky, HUV 21400!, isotypi in BPI 877339 et in HCIO.*
>
> Sporisorium mandlaicum *a specie propinque* Sporisorium queenslandicum *Vánky et al., in Vánky & Shivas, Fungal Diversity 7:159, 2001 (typus in matrice* Sehima nervosum, *Australia) distinctum racemos plerumque partim destruens, sporis magis uniformibus, majoribus, 8–10,5 × 8,5–11(–12) µm, leniter sed magis conspicue echinulatis; sporae speciei* S. queenslandicum *variables, 5,5–9 × 5,5–10 µm, punctatae usque leniter echinulatae.*

SORI (Fig. 2) destroying the raceme, often leaving intact some or many of the distal spikelets, cylindrical or curved, 1–2 × 25–60 mm, at first covered by a thick, brown peridium that flakes away and the dark brown, semiagglutinated to powdery mass of loose spore balls, spores and sterile cells is scattered leaving behind a long, simple columella, often with a few short lateral branches. SPORE BALLS of many spores, ephemeral. SPORES (Figs. 6, 7) globose, subglobose, ovoid to broadly ellipsoidal, 8–10.5 × 8.5–11(–12) µm, yellowish-brown; wall even, c. 0.8 µm thick, finely, densely echinulate, spore profile finely serrulate. STERILE CELLS (Figs. 6, 7) in irregular groups, single cells variable in shape and size, subglobose, ovoid, ellipsoidal or irregular with one or several flattened sides, 5.5–17 × 6–21 µm, subhyaline to pale yellow tinted; wall 0.5–0.8 µm thick, smooth, content homogeneous.

> On *Poaceae: Sehima nervosum* (Rottler) Stapf, S Asia (India). Known only from the type collection.

Sporisorium mandlaicum partially destroys the racemes, and has larger, more uniform spores that are finely but more evidently echinulate than *S. queenslandicum*. In *S. queenslandicum* the spores are variable, 5.5–9 × 5.5–10 µm, punctate to finely echinulate.

Key to the smut fungi of *Sehima* species

1. Sori in the leaves as dark spots; spores embedded in the host tissue, not pulverulent .... *Jamesdicksonia dactylidis*
– Sori not in the leaves; spores pulverulent 2
2. Sori in the ovaries; spores 30–37 µm in diam. .... *Tilletia sehimae*
– Sori not in the ovaries; spores smaller 3
3. Sori partially or totally destroying the inflorescence, several cm long 7
– Sori restricted to the spikelets, less than 1.5 cm long. 4
4. Spore balls ephemeral; sterile cells present .... *Sporisorium sehimicola*
– Spore balls rather persistent; sterile cells absent. 5

5. Sori in some sessile spikelets; columella 5–7; spore balls 50–160(–200) µm long . . . . ***Sporisorium sehimae***

– Sori in all sessile and pedicelled spikelets; columella 1; spore balls smaller 6

6. Spore balls 30–70(–100) µm long; spore wall uneven, 1–2(–2.5) µm, free surface finely punctate . . . . ***Sporisorium sulcati***

– Spore balls 25–50(–55) µm long; spore wall even, 0.5–0.8 µm, free surface coarsely verruculose . . . . ***Sporisorium nervosum***

7(3). Sori destroying the whole inflorescence; spores 5.5–10 µm long, punctate to finely echinulate . . . . ***Sporisorium queenslandicum***

– Sori often destroying partially the inflorescence; spores 8.5–11(–12) µm long, finely, densely echinulate . . . . ***Sporisorium mandlaicum***

A new *Sporisorium* species on *Elionurus muticus* (*Poaceae*)

Elionurus Humb. & Bonpl. ex Willd., in the subfamily *Panicoideae*, tribe *Andropogoneae*, subtribe *Rottboelliinae* has 15 species in tropical Africa and America, and one species in Australia (Clayton & Renvoize 1986:362). On *Elionurus* three smut fungi have been published: 1. ***Macalpinomyces elionuri-tripsacoidis*** Vánky, type on *E. tripsacoides* Willd., Zambia, 2. ***Sporisorium elionuri*** (Henn. & Pole-Evans) Vánky, type on *E. muticus* (Spreng.) Kuntze, South Africa, and 3. ***S. elionuri-tristis*** Vánky, type on *E. tristis* Hack., Madagascar. Ciccarone (1951:224) described ***Sphacelotheca elionuri*** Ciccar. (as '*elyonuri*') on *Elionurus argenteus* var. *caespitosus* (= *E. muticus*) from several places around Asosa and Afodu, Ethiopia. Study of the syntypes revealed that they represent a new species, which is described as:

Sporisorium ciccaronei Vánky, **nom. nov.**

MycoBank: 511643

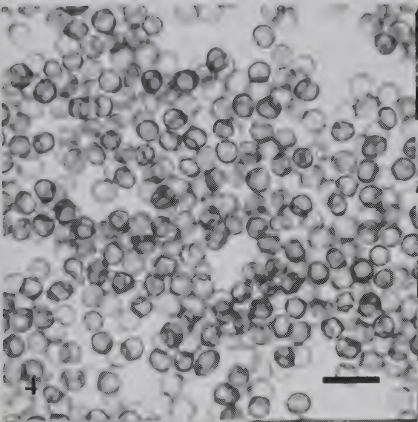
Replaced name: *Sphacelotheca elionuri* Ciccar., Mycopathol. Mycol. Appl. 5:224, 1951, as '*elyonuri*', not *Sporisorium elionuri* (Henn. & Pole-Evans) Vánky. — Type on *Elionurus argenteus* var. *caespitosus* (= *E. muticus*), Ethiopia, Benishangul-Gumuz Prov., "Asosa et Afodu", alt. c. 1600 m, III.1939, coll. A. Ciccarone. Holotype BPI 195067!, isotype BPI 177497! Both nearly completely destroyed by insects.

Sori in spiculis inflorescentiae eiusdem nonnullis, ovoidei usque longe ellipsoidales, 0,5–1 × 2–3 mm, raro inflorescentiam totam occupantes, et tunc majores, 2–4 mm × 1–5 cm, primum peridio flavidobrunneo cooperti, quo rupto massam nigrobrunneam, semiagglutinatam, granulosam usque pulveream glomerulorum sporarum laxarum, sporas et cellulas steriles columellam crassam, decrescentem, conicam, 2–3 mm longam, sulcis

Figs. 4, 5. Spores of *Tranzscheliella poae* on *Poa cita* in LM and in SEM (type).

Figs. 6, 7. Spores and sterile cells of *Sporisorium mandlaicum* on *Sehima nervosum* in LM and in SEM (type).

Figs. 8, 9. Spores and sterile cells of *Sporisorium ciccaronei* on *Elionurus muticus* in LM and in SEM (type). Bars = 10 µm.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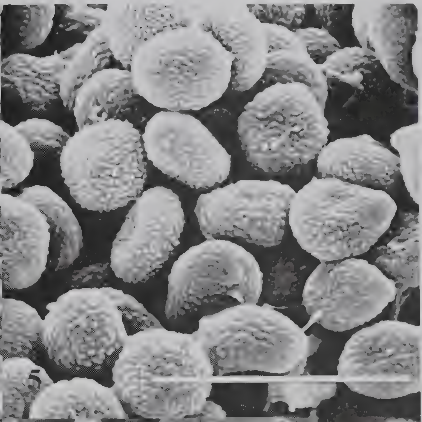
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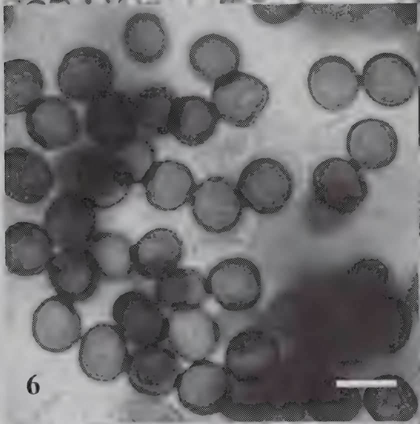
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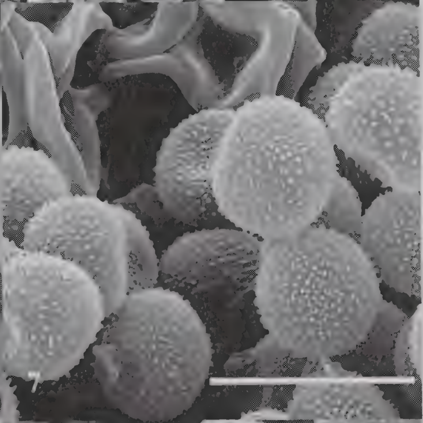
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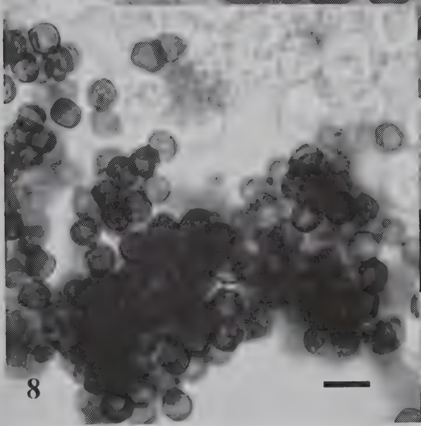
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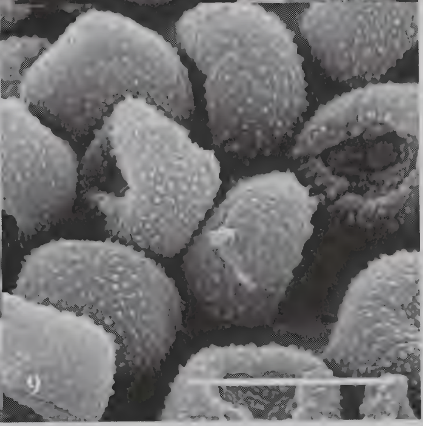
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longitudinalibus numerosis et nonnunquam cum ramis 1–2 apicularibus, spiniformibus instructam cingentes. Sporae juveniles in grandibus, laxis, irregularibus glomerulis, in statu maturo singulares, globosae, subglobosae, ovoideae, late ellipsoidales usque parum irregulares, 6–8 × 6,5–9 µm, rufobrunneae; pariete aequali, 0,8–1 µm crasso, conspicue levi usque subtiliter, dense punctato-verruculoso, imago obliqua sporae levis. Cellulae steriles globosae, ellipsoidales usque irregulares, 8–16 × 11–18,5 µm, hyalinae; pariete 2–3 µm crasso, levi.

ETYMOLOGY: named in the honour of the excellent Italian phytopathologist and collector of microfungi, Antonio S. Ciccarone (1909–1982), who also collected and described this species.

SORI (Fig. 3) in some spikelets of an inflorescence, destroying the inner floral organs, often in groups, ovoid to long ellipsoidal, 0.5–1 × 2–3 mm, rarely comprising the whole inflorescence, then larger, 2–4 mm × 1–5 cm, at first covered by a yellowish-brown peridium that ruptures from its apex disclosing the blackish-brown, semi-agglutinated, granular to powdery mass of loose spore balls, spores and sterile cells surrounding a thick, narrowing, conical, 2–3 mm long columella with numerous longitudinal furrows and sometimes with 1–2 spiniform, apical branches. SPORES (Figs. 8, 9) when young in large, loose, irregular balls, when mature single, globose, subglobose, ovoid, broadly ellipsoidal to slightly irregular, 6–8 × 6.5–9 µm, reddish-brown; wall even, 0.8–1 µm thick, apparently smooth to finely, densely punctate-verruculose, spore profile smooth. STERILE CELLS (Figs. 8, 9) globose, ellipsoidal to irregular, 8–16 × 11–18.5 µm, hyaline; wall 2–3 µm thick, smooth.

On *Poaceae*: *Elionurus muticus* (Spreng.) Kuntze (*E. argenteus* var. *caespitosus* (A. Rich.) Hack.); E Africa (Ethiopia).

Key to the smut fungi of *Elionurus* species (*Poaceae*)

1. Sori in all spikelets of an inflorescence, long cylindrical; columella filiform; sterile cells absent . . . . ***Sporisorium elionuri***

– Sori in some spikelets or ovaries of an inflorescence, or comprising the whole inflorescence; columella not filiform or absent, sterile cells present 2

2. Sori in some ovaries of an inflorescence, cylindrical; columella absent; spores with short, conical warts . . . .***Macalpinomyces elionuri-tripsacoidis***

– Sori in the spikelets or comprising the whole inflorescence; columella present; spores otherwise ornamented 3

3. Sori in some spikelets of an inflorescence; columella conical, with longitudinal furrows; spores 6.5-9 µm long, apparently smooth to finely punctate-verruculose; sterile cells 11-18.5 µm long, wall 2-3 µm thick . . . . ***Sporisorium ciccaronei***

– Sori in all spikelets of an inflorescence; columella short, simple; spores 10-13 µm long, finely, moderately densely echinulate; sterile cells 7-13 µm long, wall c. 0.5 µm thick . . . . ***Sporisorium elionuri-tristis***

A new *Sporisorium* species on *Eulalia trispicata* (*Poaceae*)

Eulalia Kunth, with c. 30 species in the Old World tropics, and *Eulaliopsis* Honda, with two species from Afghanistan to China and the Philippines, belong to the subfamily *Panicoideae*, tribe *Andropogoneae*, subtribe *Saccharinae*. *Eulalia* is related to *Saccharum*. *Eulaliopsis* is a rather isolated genus, regarded as a derivative of *Eulalia* (Clayton & Renvoize 1986:333). *Eulalia* species were often treated under the generic name *Pollinia* Spreng., nom. rejic. (= *Chrysopogon* Trin.). The smut fungi of *Eulalia* and *Eulaliopsis* were treated by me (Vánky 2000:183–186) and six species were recognised, all in the genus *Sporisorium*: 1. ***S. crypticum*** (Cooke & Massee) Vánky & M.S. Patil (type on *Pollinia argentea* (Brongn.) Trin. = *Eulalia trispicata*, India), 2. ***S. eulaliae*** (L. Ling) Vánky (type on *Eulalia trispicata*, Australia), 3. ***S. guangxiense*** L. Guo (type on *Eulalia pallens* (Hack.) Kuntze, China), 4. ***S. polliniae*** (Magnus) Vánky (type on *Pollinia distachya* (L.) Spreng., Israel), 5. ***S. pollinianum*** (Zundel) Vánky & R.G. Shivas (type on *Pollinia leptostachys* Pilg., Papua New Guinea), and 6. ***S. indicum*** (Syd. et al.) Vánky (type on *Eulaliopsis binata* (Retz.) C.E. Hubb., India). Recently, two further species have been described: 7. ***S. trispicatae*** R.G. Shivas et al. (Vánky et al. 2006:111; type on *Eulalia trispicata*, Thailand), and 8. ***S. rarum*** R.G. Shivas et al. (Shivas et al. 2007:350; type on *Eulalia aurea* (Bory) Kunth, Australia). An additional, new species, collected in Thailand, is described as:

Sporisorium shivasiorum Vánky, **sp. nov.**

MycoBank: 511644

Typus in matrice Eulalia trispicata *(det. H. Scholz, B), Thailand, Chiang Mai Prov., Mae Taeng Distr., Mae Ngad Dam, 19°09'40.5" N, 99°02'24.1" E, alt. 397 m.s.m., 28.XII.2005, leg. R.G., M.D.E., A.J., G.F. Shivas et. al. Holotypus in Herbario Ustil. Vánky, HUV 21201!, isotypus in BRIP 51766.*

Sporisorium shivasiorum a specie S. trispicatae R.G. Shivas et al., in Vánky et al., Mycol. Balcan. 3:111, 2006 (typus in matrice Eulalia trispicata, Thailand) ei arcte cognato distinctum praecipue soris, glomerulis sporarum et morphologia sporarum. Sori S. shivasiorum *in omnibus ovariis inflorescentiae eiusdem, glomeruli sporarum permanentes, sporae externae 9–12 μm longae, mediocriter atro-flavidobrunneae, in latero libero verrucis usque 0,4 μm altis. Sori speciei* S. trispicatae *in ovariis nonnullis inflorescentiae eiusdem, glomeruli sporarum faciliter in sporis dissoluti, sporae externae 10,5–14,5 μm longae, atro- flavido- usque rufo-brunneae, in latere libero verrucis usque 0,5–1 μm altis.*

Etymology: named in the honour of the family of the outstanding Australian mycologist, Dr. Roger G. Shivas, an excellent human being, a passionate collector of various groups of plant parasitic microfungi, especially smut fungi, who discovered and described numerous new species and genera, co-author of the comprehensive monograph of the Fungi of Australia. The Smut Fungi (2008). Several interesting, rare and even new species have been found by Roger's wife, Marjan D.E. Shivas, and their two daughters, Anthea and Gillian, who often accompany him on collecting trips to remote parts of Australia and overseas.

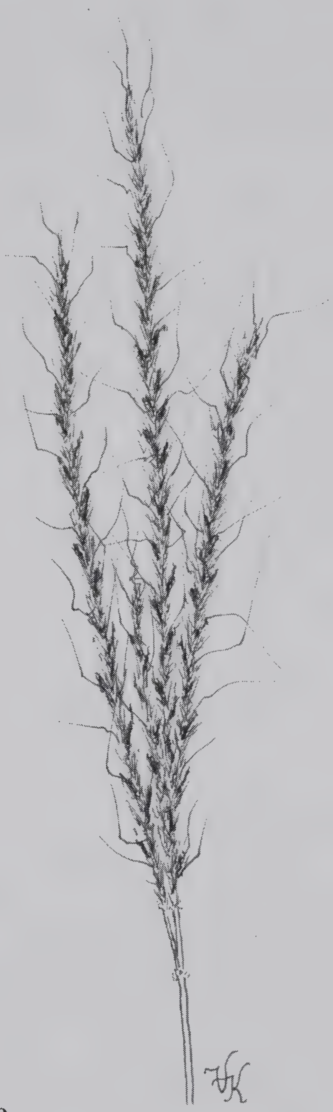

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Fig. 10. Sori of *Sporisorium shivasiorum* in the ovaries of *Eulalia trispicata* (type). Habit. Bar = 1 cm.

Sori (Fig. 10) in all ovaries of an inflorescence, long cylindrical-fusiform, 0.5–1 × 5–15 mm, bearing on their acute tip remnants of two styles with stigma, partly hidden by the floral envelopes, at first covered by a thick, yellowish-brown peridium that later ruptures longitudinally in several places, disclosing the blackish-brown, granular powdery mass of spore balls and a long, narrowing, often flattened central columella. Spore balls (Figs. 13, 14) subpolyhedrally irregular, rarely subglobose, ovoid or ellipsoidal, 30–110 × 40–150(–180) µm, reddish-brown, composed of tens or hundreds of spores that separate by pressure. Spores (Figs. 13, 14) dimorphic, outer spores subglobose, ellipsoidal to subpolyhedrally slightly irregular, 8–11.5 × 9–12 µm, medium dark yellowish-brown; wall uneven, 0.5–1(–1.5) µm thick, thickest at the angles and on the free surface, where it is evidently, densely, irregularly verrucose-echinulate, warts up to 0.4 µm high, contact sides apparently smooth to finely punctate, spore profile smooth, on the free surface finely undulate. Inner spores about the size of the outer spores, globoid to subpolyhedrally slightly irregular, pale yellowish-brown; wall even, c. 0.5 µm thick, apparently smooth to finely, densely punctate. Sterile cells absent.

On *Poaceae: Eulalia trispicata* (Schult.) Henrard; SE Asia (Thailand). Known only from the type collection.

Key to the smut fungi (*Sporisorium*) of *Eulalia* and *Eulaliopsis*

1. Spore balls ephemeral; sterile cells present 2
– Spore balls semi-permanent; sterile cells absent 5
2. Spores 9.5–13 µm long . . . . *S. pollinianum*
– Spores less than 9.5 µm long 3
3. Sori in the whole inflorescence. On *Eulaliopsis* . . . . *S. indicum*
– Sori in the spikelets. On *Eulalia* 4
4. Spores 5.5–9 µm long; wall uneven, 0.5–1.5 µm thick, in SEM densely verrucose, warts of the same kind . . . . *S. guangxiense*
– Spores 7–9.5 µm long; wall even, 0.5 µm thick, in SEM moderately densely echinulate, between the spines minutely verruculose . . . . *S. rarum*
5. Spore balls 25–55 µm long, of few spores (10–40?); spores 8–14 µm long . . . . *S. polliniae*
– Spore balls larger, of more spores; spores larger 6
6. Outer spores up to 20 µm long, spore wall 1–3 µm thick . . . . *S. crypticum*
– Outer spores up to 15 µm long; spore wall thinner 7
7. Sori in spikelets (all); spore wall 1–2(–2.5) µm thick . . . . *S. eulaliae*
– Sori in ovaries (some or all of an inflorescence); spore wall 0.5–1.5 µm thick . . . 8
8. Sori in some ovaries of an inflorescence; spore balls easily separating into spores; outer spores 10.5–14.5 µm long, with 0.5–1 µm high warts . . . . *S. trispicatae*
– Sori in all ovaries of an inflorescence; spore balls permanent; outer spores 9–12 µm long, with up to 0.4 µm high warts . . . . *S. shivasiorum*

A new *Thecaphora* species on *Arnica pumila* (*Asteraceae*)

Thecaphora californica and *T. cuneata* are known from the USA on *Grindelia* spp. A smut fungus, collected on *Arnica pumila,* was also attributed to *T. californica* by Fischer (1953:154). A study of the specimen shows that it is specifically distinct and it is described as:

Thecaphora arnicae Vánky, **sp. nov.**

MycoBank: 511645

Typus in matrice Arnica pumila, *USA, Colorado, Boulder, 19.VI.1919, leg. E. Bethel (ut* Thecaphora *sp.). Holotypus WSP 34598!*

Thecaphora arnicae *distincta* T. californica *(Harkn.) G.P. Clinton, J. Mycol. 8:146, 1902 (typus in matrice* Grindelia robusta, *USA) ei proxime relativae speciei glomerulis sporarum majoribus (17–45(–50) µm longis) et (1–)3–25 sporis compositis, sporis majoribus (12–15 (–17) × 13–20(–24) µm, radialiter 10,5–20 µm longis, et ad superficiem liberam pariete crassiore (2,5–3,5 µm). In* Thecaphora californica *glomeruli sporarum 22–40 µm longi, e 6–20 (vel pluribus?) sporis compositi, sporae 9,5–13,5 × 9,5–15(–17) µm, radialiter 9,5–17,5 µm longae, pariete ad superficiem liberam 1,5–2,5 µm crasso.*

Sori in the flower heads. Spore balls (Figs. 15, 16) globose, subglobose, ovoid, ellipsoidal, 15–45 × 17–45(–50) µm, pale yellowish-brown, composed of (1–) 3–25 firmly united spores. Spores (Figs. 15, 16) subcuneiform, in surface view rounded subpolygonally irregular, more rarely ovoid or elongated, 12–15(–17) × 13–20(–24) µm, radially 10.5–20 µm long, yellow to pale yellowish-brown; wall of contact sides c. 0.5 µm thick, smooth, on the free surface 2.5–3.5 µm thick, provided with irregular spiny warts, up to 1.5 µm high, isolated or usually confluent at their base into an irregular pattern.

On *Asteraceae: Arnica pumila* Rydb.; N America. Known only from the type collection.

Thecaphora arnicae differs from the closely related *T. californica* (Harkn.) G.P. Clinton (1902:146; type on *Grindelia robusta* Nutt., USA), in having larger spore balls (17–45(–50) µm long), composed of (1–)3–25 spores, larger spores (12–15(–17) × 13–20(–24) µm, radially 10.5–20 µm long), and thicker wall of the free surface (2.5–3.5 µm). In *T. californica* the spore balls are 22–40 µm long, composed of 6–20(or more?) spores, the spores are 9.5–13.5 × 9.5–15(–17) µm, radially 9.5–17.5 µm long, the wall of the free surface is 1.5–2.5 µm thick. *T. arnicae* differs also from *T. cuneata,* in which the spore balls are 35–60(–70) µm long, composed of 15 to several tens of firmly united spores, which radially are 12–26 µm long, with a 2.5–4(–5) µm thick spore wall on the free surface.

A new *Ustilago* species on *Milium vernale* (*Poaceae*)

Milium L. is a grass genus of 4 species in the tribe *Stipeae* of the subfam. *Pooideae* (Clayton & Renvoize 1986:85). On *Milium* several smut fungi have been described representing two species: ***Tilletia milii-vernalis*** Liro (Liro 1939:113; type on *M. vernale,* Turkey), and ***Ustilago milii*** (Fuckel) Liro (Liro 1924:78; = ***U. striiformis***; type on *M. effusum* L., Germany). A different species, with peculiar sori was found recently in the Herb. B (Berlin), which is described as:

Ustilago milii-vernalis Vánky & H. Scholz, **sp. nov.**

MycoBank: 511646

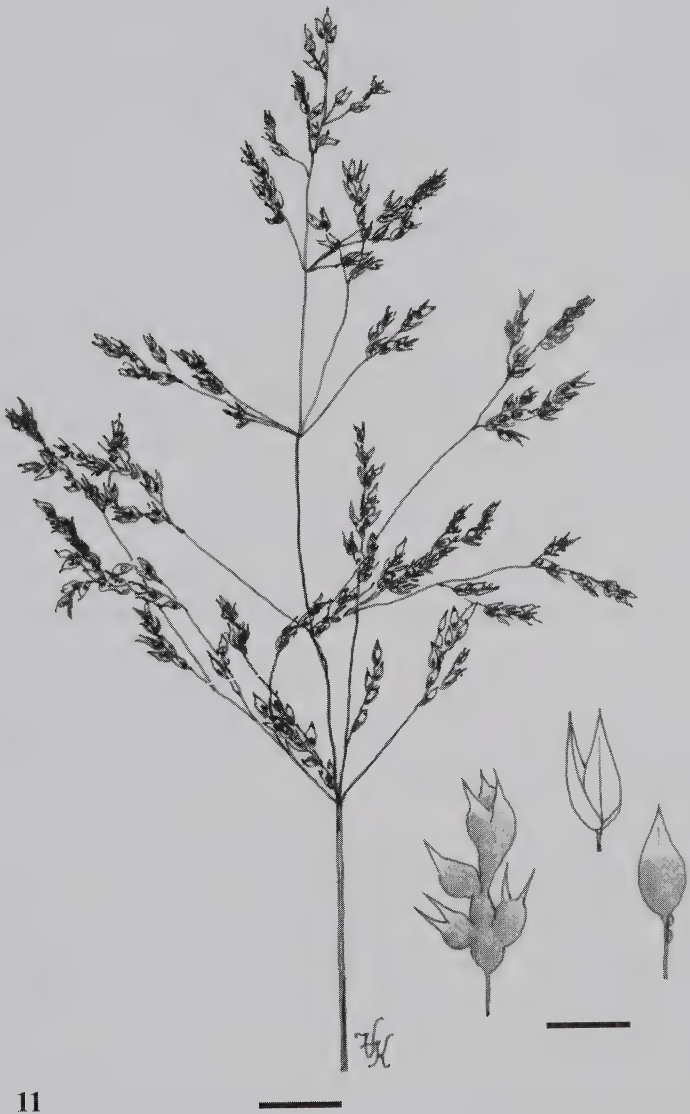

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Fig. 11. Sori of *Ustilago milii-vernalis* in the spikelets and floral pedicels of *Milium vernale* (type). Habit, and enlarged a healthy spikelet, an infected spikelet and a group of four infected spikelets in which the sori comprise also the floral pedicels.

Bars = 1 cm for habit, and 2 mm for detail drawing.

Typus in matrice Milium vernale, *Graecia, Makedonia, Florina, NW oppid. Ammohori, 40°46'24" N, 21°30'0.5" E, alt. 615 m.s.m., 10.V.2004, leg. R. et E. Willing 126494. Holotypus in HUV 21458, isotypus in B.*

Sori in spiculis tumores cinerei, bullati ad basin involucrorum floralium omnium, saepe etiam ad pedicellos floralios, raro etiam fere ad involucra omnia, intacte apicem illorum tantum relinquentes, prius epidermide tenuo cooperti, quo irregulariter rupto massam brunneam, pulveream sporarum ostendentes. Vulgo spiculi omnes rami inflorescentiae eiusdem affecti, cum ramis salvis permiscenter. Tam non raro spiculi pauci eiusdem rami inflorescentiae tantum affecti. Sporae globosae, subglobosae, ovoideae vel ellipsoideae, raro parum irregulares, 6,5-8 × 6,5-9,5(-11) µm, pallide flavido-brunneae; pariete inaequali, cca. 0,4 µm in latere uno, cca. 0,8 µm in parte dimidia opposita, qua spora etiam atrior, superficies eius leniter, dense punctata-verruculosa, imago obliqua sporae in latere atriore levis, in latere pallidiore leniter, dense undulata.

SORI (Fig. 11) in the spikelets as grey, bullate swellings on the base of all floral envelopes, often also on the floral pedicels, rarely comprising nearly the whole floral envelopes leaving intact only their tip, at first covered by the thin epidermis that ruptures irregularly disclosing the brown, powdery mass of spores. Commonly all spikelets of an inflorescence branch are affected, which are mixed with healthy branches. However, not rarely only a few spikelets of a certain inflorescence branch are infected. SPORES (Figs. 17, 18) globose, subglobose, ovoid or ellipsoidal, rarely slightly irregular, 6.5–8 × 6.5–9.5(–11) µm, pale yellowish-brown; wall uneven, c. 0.4 µm on one side, c. 0.8 µm on the opposite half, where the spore is also darker, surface finely, densely punctate-verruculose, spore profile smooth on the darker side, finely, densely wavy on the paler side.

On *Poaceae: Milium vernale* M. Bieb., S Europe. Known only from the type collection.

Ustilago milii-vernalis has unique morphology and distribution of the sori. These characteristics, in combination with the spore morphology, differentiate it from all known *Ustilago* species on *Poaceae.*

A new *Ustilago* species on *Sclerachne punctata* (*Poaceae*)

Sclerachne R. Br. is a genus with only one known species, *S. punctata,* in the subtribe *Chionachninae* of the tribe *Andropogoneae* (Clayton & Renvoize 1986:371). No smut fungus is known on *Sclerachne.* A meagre specimen is preserved in BPI, under the herbarium name *Sphacelotheca sclerachnes* Wakef., which is described as:

Ustilago sclerachnes Wakef. ex Vánky, **sp. nov.**

MYCOBANK: 511647

Sphacelotheca sclerachnes Wakef., nom. herb. — Typus in matrice *Sclerachne punctata,* Thailand, Bangkok, 10.XI.1929, no further data. Holotypus BPI 195063! (a single sorus).

Sori in ovariis, cca. 2 × 4 mm, anguste ovoidei, inter involucra floralia distantes conspicui, primum peridio pallide brunneo cooperti, quo irregulariter rupto massam pulveream *fusco-brunneam sporarum ostendentes. Sporae globosae vel subglobosae, raro late ellipsoidales, 5–6,5 × 5,5–6,5 µm, mediocriter atro-flavidobrunneae; pariete aequali, cca. 0,5 µm crasso, valde leniter, moderate dense punctato usque punctato-verruculoso, imago obliqua sporarum levis. Cellulae steriles absentes.*

SORI in ovaries (Fig. 12), c. 2 × 4 mm, narrow ovoid, showing between the spreading floral envelopes, at first covered by a pale brown peridium that ruptures irregularly disclosing the blackish-brown, powdery mass of spores. SPORES (Figs. 19, 20) globose or subglobose, rarely broadly ellipsoidal, 5–6.5 × 5.5–6.5 µm, medium dark yellowish-brown; wall even, c. 0.5 µm thick, very finely, moderately densely punctate to punctate-verruculose, spore profile smooth. STERILE CELLS absent.

On *Poaceae: Sclerachne punctata* R. Br. (*Chionachne punctata* (R. Br.) Jannink; *Polytoca punctata* (R.Br.) Stapf); SE Asia. Known only from the type collection.

Ustilago sclerachnes differs from all known smut fungi on members of the closely related *Chionachne* and *Polytoca*, as shown in the key below.

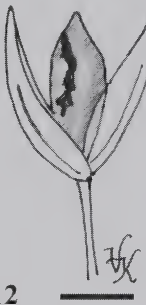


Fig. 12. A sorus of *Ustilago sclerachnes* in the ovary of *Sclerachne punctata* (type). Bar = 2.5 mm. **12**

Key to the smut fungi of *Chionachne, Polytoca* and *Sclerachne*

1. Sori in the ovaries 2
– Sori in the spikelets or in the whole inflorescence 5

2. Spores 32–50 µm long . . . . *Tilletia puneana*
– Spores smaller 3

3. Spores 23–36 µm long . . . . *Tilletia chionachnes*
– Spores smaller 4

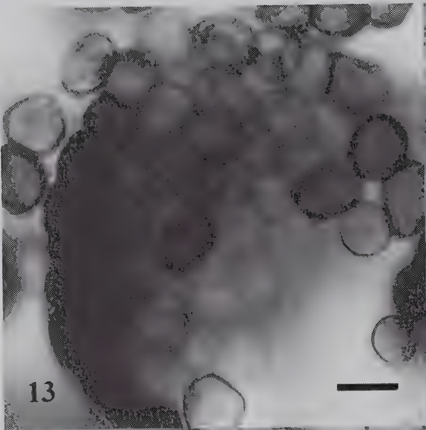
4. Spores 16–24(–26) µm long. . . . . *Tilletia kimberleyensis*
– Spores 5.5–6.5 µm long . . . . *Ustilago sclerachnes*

5. Sori in the whole inflorescence; columella much branched 6
– Sori in the spikelets; columella not much branched 7

6. Spores 8–10.5 µm long, prominently echinulate . . . . *Sporisorium simile*
– Spores 10.5–14.5 µm long, densely, minutely echinulate *Sporisorium reilianum*

7. Spores 6.5–11 µm long. . . . . *Sporisorium polytocae-barbatae*
– Spores larger 8

8. Spores 11–15 µm long, mostly subpolyhedrally irregular, finely punctate-echinulate, spore profile smooth to finely serrulate . . . . *Sporisorium polytocae*
– Spores 9.5–16(–19) µm long, mostly rounded, evidently echinulate; spore profile serrate . . . . *Sporisorium polytocae-digitatae*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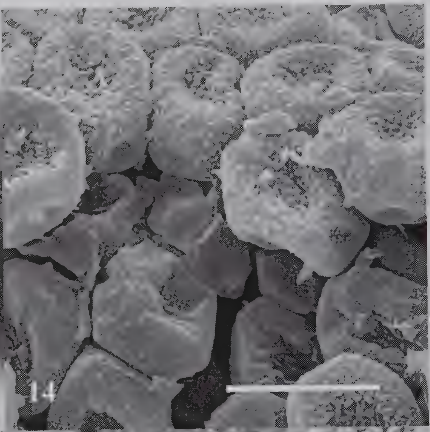
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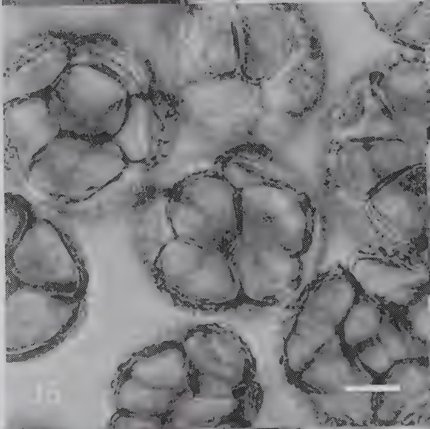
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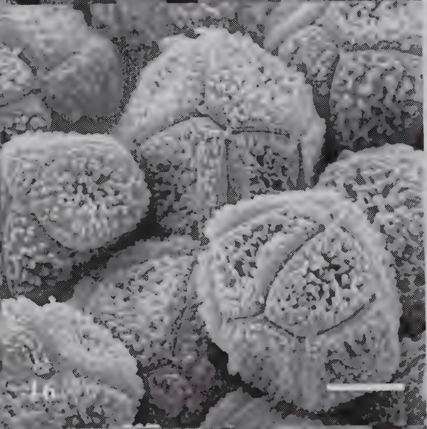
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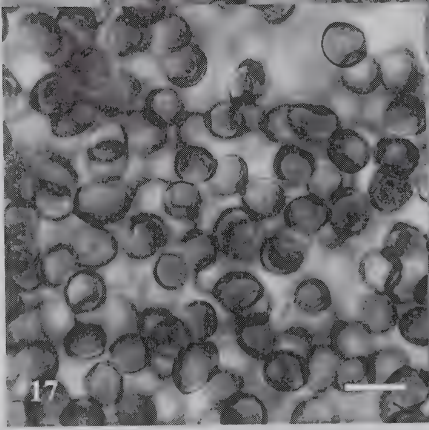
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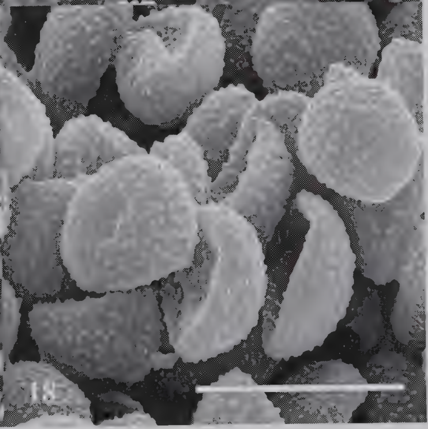
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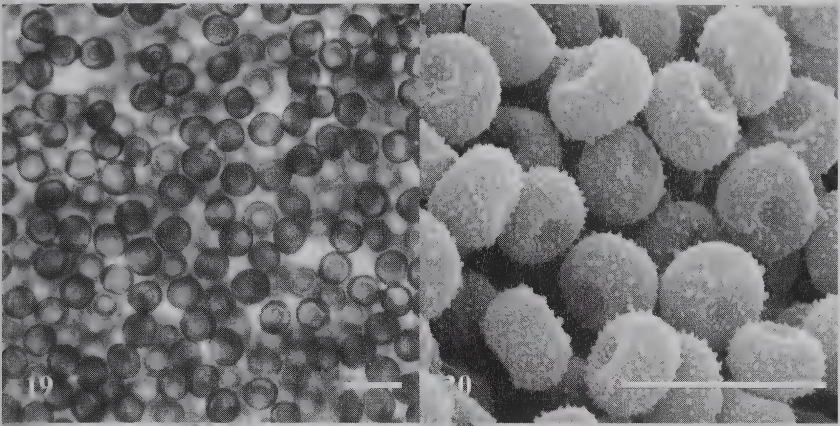
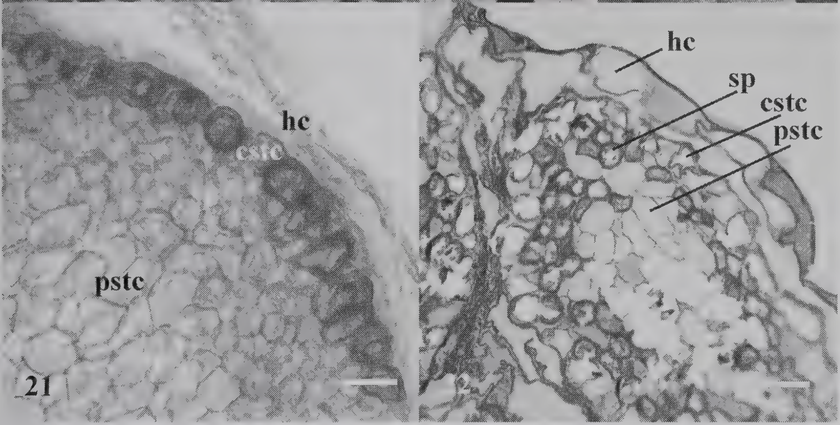


Figs. 19, 20. Spores of *Ustilago sclerachnes* on *Sclerachne punctata* in LM and in SEM (type).

Bars = 10 µm.



Figs. 21, 22. Sectioned spore balls of *Doassansiopsis guangdongensis* on *Sagittaria* sp. in LM (type). Fig. 21. Hand-cut, not stained. Fig. 22. Embedded in resin, thin-sectioned (0.7 µm) and stained with new fuchsin and crystal violet (as described in Vánky et al. 2008, 172). hc = host plant cells, cstc = cortical sterile cells, sp = spores, pstc = parenchymatous sterile cells.

Bars = 10 µm.

Figs. 13, 14. Spore balls and spores of *Sporisorium shivasiorum* on *Eulalia trispicata* in LM and in SEM (type).

Figs. 15, 16. Spore balls and spores of *Thecaphora arnicae* on *Arnica pumila* in LM and in SEM (type).

Figs. 17, 18. Spores of *Ustilago milii-vernalis* on *Milium vernale* in LM and in SEM (type).

Bars = 10 µm.

New combinations

Thecaphora bulbinellae is a *Urocystis* (*Urocystidaceae*)

Talbot (1958:111) described a smut fungus on *Bulbinella setosa* (*Liliaceae* s. lat.), under the name *Thecaphora bulbinellae*. It produces large, permanent, dark reddish-brown spore balls in the flowers. According to Talbot, the spore balls are composed of 20 to numerous spores. As all 58 known species of *Thecaphora* infect dicotyledonous host plants, *T. bulbinellae* was investigated. Spore balls bleached with hydrogen peroxide (H_2O_2) revealed that they were composed of numerous spores surrounded by a single layer of dark coloured sterile cells. Spore germination is not known and DNA analysis from old specimens was not possible. Ultrastructural analyses revealed haustoria and simple septal pores with membraneous caps and bands, typical, i.a., for the *Urocystidaceae* Begerow et al. The genus *Urocystis* Rabenh. ex Fuckel is a large genus with 170 known species parasitising both monocotyledonous and eudicotyledonous host plants in 29 families. The sterile cells in the spore balls of *Urocystis* species are usually hyaline or pale yellowish-brown. Dark, reddish-brown sterile cells in *Urocystis* are rare (e.g. *U. junci* Lagerh.). Based on the results, *T. bulbinellae* is transferred into the genus *Urocystis* as:

Urocystis bulbinellae (P.H.B. Talbot) Vánky, M. Lutz, R. Bauer & Piątek, **comb. nov.**
MycoBank: 511648

> Basionym: *Thecaphora bulbinellae* P.H.B. Talbot, Bothalia 7:111, 1958. — Type on *Bulbinella setosa* (= *B. nutans*), South Africa, Pretoria, Struben's Valley, 24.VI.1957, J. Toxopeus. Holotype PREM 41745, isotype HUV 21442!

Sori in all flowers of an inflorescence replacing the seeds with a black, granular-powdery mass of spore balls, enclosed by the floral envelopes. Spore balls globose, subglobose, ellipsoidal to slightly irregular, 25–40 × 25–50 µm, yellowish to dark reddish-brown, composed of 20 to several tens of firmly agglutinated spores surrounded by a layer of darker, larger, thick-walled sterile cells, collapsed in dry specimens. Spores varying in shape and size, globose, subglobose, ovoid, usually subpolyhedrally irregular, 4–8 × 5–12 µm, pale yellowish-brown; wall even, c. 0.5 µm thick, smooth. Sterile cells varying in shape and size, globose, ellipsoidal, ovoid to elongated or slightly irregular, 5–12 × 5.5–15 µm, medium dark reddish-brown; wall uneven, c. 0.5–2.5(–3) µm thick, smooth on both contact and free surfaces. Spore germination not known.

> On *Asphodelaceae* (*Liliaceae* s. l.): *Bulbinella nutans* (Thunb.) T. Durand & Schinz (*B. robusta* Kunth; *B. setosa* (Willd. ex Schult.f.) T. Durand & Schinz; *Anthericum setosum* Willd. ex Schult.f.); S Africa, two localities.

Urocystis bulbinellae deviates from typical *Urocystis* in having relatively small, thin-walled, pale coloured spores of variable shape and size. Furthermore, it differs in having dark, thick-walled sterile cells. Spore ball building is also different.

The generic position of *Schizonella isolepidis*

by Kálmán Vánky & Matthias Lutz

A peculiar smut fungus was described on the stems of *Isolepis nodosa* (= *Ficinia nodosa; Cyperaceae*) from New Zealand, under the name ***Schizonella isolepidis*** Vánky (Vánky & McKenzie 1990:251). The authors also discussed this fungus and showed that *S. isolepidis* differs in several features from the other three, rather uniform species of *Schizonella.* They concluded that its generic position was uncertain.

To determine the phylogenetic position of *Schizonella isolepidis* the ITS and LSU rDNA sequences of the type specimen of *S. isolepidis* were compared with a dataset containing representatives of the *Ustilaginales*, including all *Schizonella* and *Tolyposporium* species that had ITS and LSU sequences on GenBank. Additionally we sequenced and analysed DNA of a specimen of *Tolyposporium neillii* (G. Cunn.) Vánky & McKenzie (on *Ficinia nodosa*, New Zealand, Stewart Island, Mason Bay, alt. c. 10 m, 14.II.1998, leg. E.H.C. McKenzie, C. & K. Vánky, HUV 18533). For methods of DNA extraction, PCR and sequencing see Lutz et al. (2004), for methods of phylogenetic analyses see Vánky et al. (2008). GenBank accession numbers are given in Fig. 23.

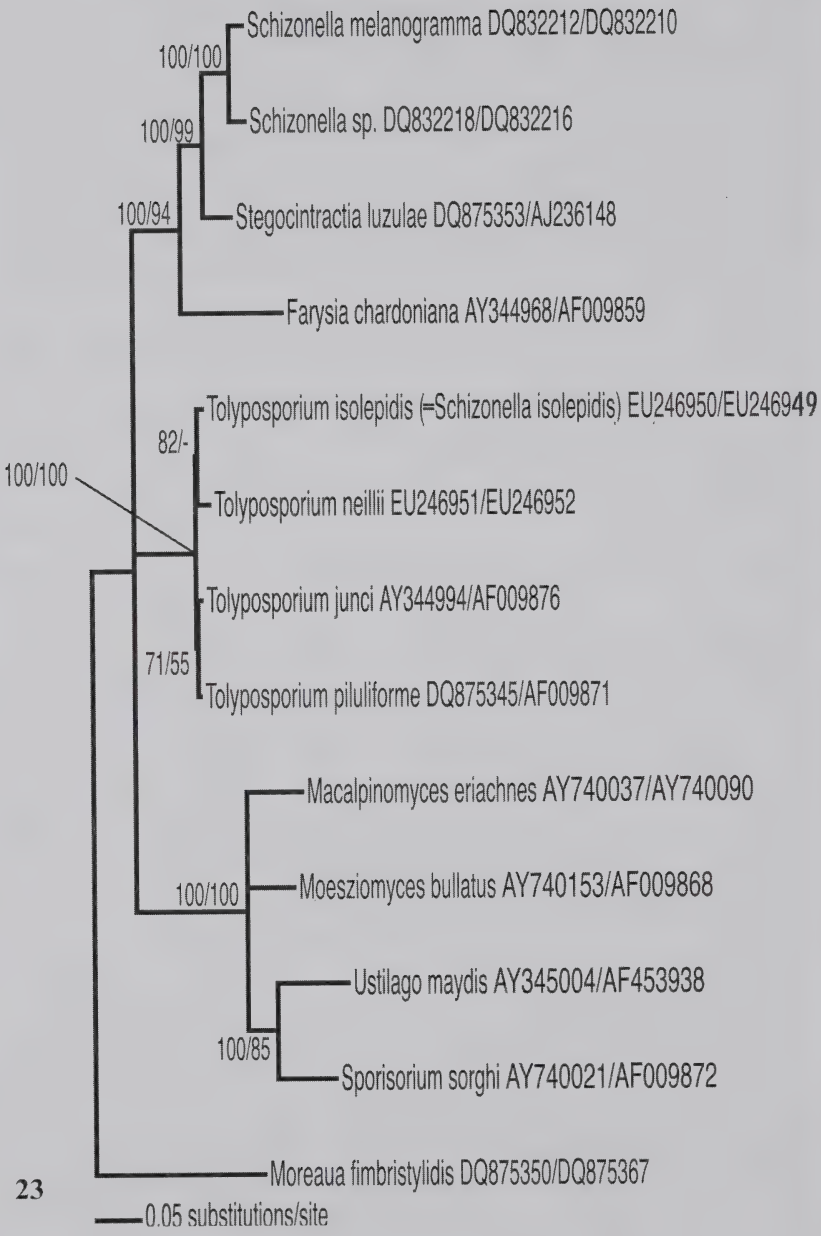
The results of the molecular analyses are depicted in Fig. 23. *Schizonella isolepidis* clusters as sister taxon of *Tolyposporium neillii* within a group containing all *Tolyposporium* species sampled. In addition, *Schizonella isolepidis* is well separated from *Schizonella* species. The morphological differences of *Schizonella isolepidis* and *Tolyposporium neillii*, both growing on the same host plant, correspond to considerable differences in the ITS and LSU nucleotide sequences (19 + 7 base pairs differences between the two species). Consequently, the following transfer is proposed:

Tolyposporium isolepidis (Vánky) Vánky & M. Lutz, **comb. nov.**

MycoBank: 511649

Basionym: *Schizonella isolepidis* Vánky, in Vánky & McKenzie, New Zealand J. Bot. 28:251, 1990. — Type on *Isolepis nodosa* (= *Ficinia nodosa*), New Zealand, North Island, Bay of Plenty, Moutohora (Whale Island), 4.I.1986, leg. R.E. Beever, Holotype HUV 14720, isotype PDD 56371.

Sori as small, subepidermal pustules on stems, often confluent, up to 10–15 cm long and surrounding the stems, at first lead-coloured, later the epidermis flakes away, exposing the black, granular, semi-powdery mass of spores and spore balls. Spores often in pairs or in balls of up to 10 spores, but isolated spores are also present. Spore balls irregular, 13–20 × 18–45 µm, dark reddish-brown, opaque. Mycelial remnants often present around the spore balls,


Schizonella melanogramma DQ832212/DQ832210
100/100
Schizonella sp. DQ832218/DQ832216
100/99
Stegocintractia luzulae DQ875353/AJ236148
100/94
Farysia chardoniana AY344968/AF009859
Tolyposporium isolepidis (=Schizonella isolepidis) EU246950/EU246949
82/-
100/100
Tolyposporium neillii EU246951/EU246952
Tolyposporium junci AY344994/AF009876
71/55
Tolyposporium piluliforme DQ875345/AF009871
Macalpinomyces eriachnes AY740037/AY740090
Moesziomyces bullatus AY740153/AF009868
100/100
Ustilago maydis AY345004/AF453938
100/85
Sporisorium sorghi AY740021/AF009872
Moreaua fimbristylidis DQ875350/DQ875367
0.05 substitutions/site

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and spores. Spores very irregular in shape and size, subglobose, elongated, subpolyangular to usually irregular, often with a flattened side, 10–16 × 14–24 µm, dark reddish-brown; wall unequally thickened, 1–5 µm wide, sometimes with protuberances and light-refractive areas at the angles, surface irregularly reticulate to cerebriform, meshes often incomplete. In SEM surface irregularly ornamented by a combination of large, often incomplete meshes and warts. Spore germination unknown.

On *Cyperaceae: Ficinia nodosa* (Rottb.) Goethg. et al. (*Scirpus nodosus* Rottb.; *Isolepis nodosa* (Rottb.) R. Br.); New Zealand.

Ustilago duriusculae is *U. striiformis*

by Kálmán Vánky & Matthias Lutz

Guo (2006:162) published *Ustilago duriusculae* on *Carex duriuscula* subsp. *rigescens* (Franch.) S.Yun Ling & Y.C. Tang, from China, Qinghai Prov., Minhe, Langtang, alt. 2580 m, 9.VIII.2004, coll. L. Guo & W. Li 2698. Holotype HMAS 95452, isotype HUV 20951! Paratype HMAS 95453, isoparatype HUV 20952! The fungus produces long striae on the leaves between the veins, at first covered by the epidermis that ruptures disclosing the dark brown, powdery mass of spores. Spores subglobose, ellipsoidal, ovoid to slightly irregular, 7.5–12 × 8–15 µm, yellowish- to reddish-brown; spore wall even, c. 1 µm thick, finely echinulate.

Guo (2006:162) remarked that the fungus "is close to *Ustilago striiformis* (Westend.) Niessl on *Poaceae* from which it differs in parasitising different host family." Unfortunately, the infected plants are sterile. Attempts to obtain base sequences from fungal DNA failed. However, the 5′-end of the nuclear large subunit ribosomal DNA (LSU) of the host plant was sequenced. (for methods of DNA extraction, PCR and sequencing see Lutz et al. (2004), (GenBank accession number: EU246953). Blast searches (Altschul et al. 1997) revealed closest similarity of the sequence to sequences of *Poaceae*. Consequently, ***Ustilago duriusculae*** L. Guo is considered to be a synonym of ***U. striiformis*** (Westend.) Niessl (syn. nov. by Vánky & M. Lutz) and it remains valid, that *Ustilago* spp. are restricted to members of the *Poaceae*.

Fig. 23. Bayesian inference of phylogenetic relationships within the sampled *Ustilaginales*: Markov chain Monte Carlo analysis of an alignment of ITS and LSU rDNA base sequences using the GTR+I+G model of DNA substitution with gamma distributed substitution rates and estimation of invariant sites, random starting trees and default starting parameters of the DNA substitution model. A 60% Majority-rule consensus tree computed from 18 000 trees that were sampled after the process had reached stationarity is shown. The topology was rooted with *Moreaua fimbristylidis*. Numbers on branches before slashes are estimates for *a posteriori* probabilities, numbers on branches after slashes are percentage bootstrap values of 1000 replicates. Branch lengths were averaged over the sampled trees. They are scaled in terms of expected numbers of nucleotide substitutions per site. (Prepared by M. Lutz).

About the genus *Melanotaenium* (*Melanotaeniaceae*)

The genus *Melanotaenium* de Bary (Bary 1874:105), with its type *M. endogenum* on *Galium mollugo* (*Rubiaceae*), was described for a *Protomyces*- or *Entyloma*-like fungus. It has single, dark coloured spores embedded in the host tissue. Successively, a large number of parasitic microfungi representing a heterogeneous assemblage from many different host plants have been transferred into or described in *Melanotaenium*. Based on morphological, biological, ultrastructural and molecular characters, as well as on host plant criteria, of the c. 60 *Melanotaenium* species remained eleven. These are: 1. ***M. adoxae*** (Bref.) S. Ito, type on *Adoxa moschatellina* L. (*Adoxaceae*), Germany, 2. ***M. antirrhini*** Vienn.-Bourg. ex Vánky, type on *Antirrhinum latifolium* Mill. (*Scrophulariaceae*), France, 3. ***M. arnaudianum*** Cif., type on *Helleborus niger* L. (*Ranunculaceae*), Italy, 4. ***M. cingens*** (Beck) Magnus, type on *Linaria genistifolia* (L.) Mill. (*Scrophulariaceae*), Austria, 5. ***M. endogenum*** (Unger) de Bary, type on *Galium mollugo* L. (*Rubiaceae*), Austria, 6. ***M. euphorbiae*** (L.W. Lenz) M.D. Whitehead & Thirum., type on *Euphorbia heterophylla* L. (*Euphorbiaceae*), USA, 7. ***M. gunnerae*** G.P. Clinton ex Vánky & R. Bauer, type on *Gunnera magellanica* Lam. (*Gunneraceae*), Chile, 8. ***M. hypogaeum*** (Tul. & C. Tul.) Schellenb., type on *Linaria spuria* (L.) Mill. (= *Kickxia spuria* (L.) Dumort; *Scrophulariaceae*), France, 9. ***M. jaapii*** Magnus, type on *Teucrium montanum* L. (*Lamiaceae*), Germany, 10. ***M. spermacoces*** Thirum. et al., type on *Spermacoce hispida* (*Rubiaceae*), India, and 11. ***M. tochinaianum*** S. Ito, type on *Peracarpa carnosa* Hook. f. & Thomson (*Campanulaceae*), Japan.

With the exception of *M. arnaudianum* and *M. spermacoces*, species typically have sori that are swollen, forming pustules, swellings, sometimes considerable tumours, usually on the stems and also on the hypocotyls, petioles and in the leaf veins or leaves, the spores are relatively large, up to 20, 24 or even 28 µm long, dark reddish-brown, with a two-layered, up to 2.5 or 4, rarely 5.5 µm thick wall (comp. also Vánky 2002:98). In contrast, *M. arnaudianum* and *M. spermacoces* form spots on the leaves, and the spores are small, 9–11, respectively 7.5–12.5 µm. The spore wall in *M. arnaudianum* is only 1–1.5 µm thick, and the spores are hyaline or brownish. According to Ciferri (1924a:58), Arnaud found this fungus on *Helleborus* near Savoia and considered it to be *Entyloma ranunculi*. Based on the description, and after comparison with the other *Melanotaenium* species, I consider that the place of *M. arnaudianum* is within the genus *Entyloma* as:

Entyloma arnaudianum (Cif.) Vánky, **comb. nov.**

MycoBank: 511650

Basionym: *Melanotaenium arnaudianum* Cif., Bull. Soc. Bot. Ital. 1924:58, 1924. — Type on *Helleborus niger*, Italy, Pausula, near Macerata, date? coll. R. Ciferri (type where?).

Sori in leaves and petioles as elongate spots with indefinite margins, up to 5 cm long or longer by confluence, initially pale then reddish-brown or brownish violet, covered by the epidermis. Spores intercellular, globose, 9–11 µm in diam., at first hyaline, later brownish, contents sometimes guttulate; wall two-layered, 1–1.5 µm thick, smooth. [No material was available for study. Description taken from the original.]

On *Ranunculaceae: Helleborus niger* L.; Europe (France, Italy).

Regarding ***Melanotaenium spermacoces*** (Thirumalachar et al. 1956:10), it was described on *Spermacoce hispida* L., from India, Bombay, Ambernath, 15.VIII.1954, coll. M.K. Patel, G.W. Dhande & V.V. Bhatt. (type where?, not in HCIO, BPI, IMI). The original description is summary: "Sori forming dull grey, diffuse, circular leaf spots without inciting malformation of the host. Spores scattered in the intercellular spaces of the mesophyll, deep olivaceous-brown, 7.5–12.5 µm in diam., with a small hyphal appendage attached to one end. Spore germination unknown."

Furthermore, the authors remarked that the "Infection is confined mostly to lower leaves". "The spores are developed sparsely at the end of the hyphal branches. A small remnant of the hyphae remains persistent appearing as a small hyphal appendage". "The spores are loosely grouped and very small in size". These characters exclude *Melanotaenium spermacoces* not only from the genus *Melanotaenium* but also from the smut fungi (excluded here).

Key to the species of *Melanotaenium,* based on host taxonomy

On ***Adoxaceae:*** *Adoxa*; in stems, rhizomes and leaves .... ***M. adoxae***
On ***Campanulaceae:*** *Peracarpa*; on stems .... ***M. tochinaianum***
On ***Euphorbiaceae:*** *Euphorbia*; on stems .... ***M. euphorbiae***
On ***Gunneraceae:*** *Gunnera*; on petioles and leaf veins .... ***M. gunnerae***
On ***Lamiaceae:*** *Galeopsis, Lamium, Teucrium,*
    on underground stems and hypocotyls .... ***M. jaapii***
On ***Rubiaceae:*** *Asperula, Galium,* on stems and leaves .... ***M. endogenum***
On ***Scrophulariaceae:***

1. On *Antirrhinum*; on stems; spores 14–20 µm long; wall more or less evenly thickened, 1.5–2 µm wide .... ***M. antirrhini***
– Not on *Antirrhinum*; spores 16–24 µm long 2
2. On *Kickxia*; on hypocotyl as large, cylindrical swelling .... ***M. hypogaeum***
– On *Linaria*; on stems and leaves as pustules .... ***M. cingens***

Tuburcinia simplex is a good species in *Urocystis* (*Urocystidaceae*)

On species of *Anemone* (*Ranunculaceae*) several *Urocystis* species have been described. The following eight species could be recognised: 1. ***U. anemones***

(Pers. : Pers.) G. Winter (Winter 1880:160; type on *A. nemorosa* L., Germany), 2. ***U. antipolitana*** Magnus (Magnus 1879:214; type on *A. coronaria* L., France), 3. ***U. antucensis*** (Liro) Piątek (Piątek 2007:93; type on *A. antucensis* Poepp., Chile), 4. ***U. japonica*** (Henn.) L. Ling (1945:3; type on *A. japonica* Siebold & Zucc., Japan), 5. ***U. novae-zelandiae*** (G. Cunn.) G. Cunn. (1945:344; type on *A. tenuicaulis* (Cheeseman) Parkin & Sledge, New Zealand), 6. ***U. subnuda*** (Liro) Zundel (Zundel 1953:334; type on *A. cylindrica* A. Gray, USA), 7. ***U. pseudoanemones*** Denchev et al. (Denchev et al. 2000:453; type on *A. flaccida* F. Schmidt, Japan), and 8. ***U. sinensis*** L. Guo (Guo 2005:270; type on *A. rivularis* Buch.-Ham. ex DC., China).

An additional smut fungus, described by Liro as *Tuburcinia simplex* on *Anemone caroliniana,* belongs to the genus *Urocystis* as:

Urocystis simplex (Liro) Vánky, **comb. nov.**

MycoBank: 511651

Basionym: *Tuburcinia simplex* Liro, Ann. Univ. Fenn. Abo., Ser. A, 1:59, 1922. — Type on *Anemone caroliniana*, USA, Texas, Austin, 13.III.1901, W.H. Long, Holotype in H!, isotype BPI 181309.

Sori on leaves forming pustules up to 1 cm in diam., at first covered by the epidermis that ruptures irregularly disclosing the black mass of spores and spore balls. Spore balls composed of 1, rarely 2 spores, usually naked or with a few sterile cells. Spores globose, ovoid, ellipsoidal or slightly irregular, 11–15 × 13–19 µm, reddish-brown; wall 0.8–1.2 µm thick, apparently smooth. Sterile cells globoid to elongated, 10–19 µm long, yellowish-brown; wall 1–3 µm thick, smooth, collapsed in old specimen.

On *Ranunculaceae: Anemone caroliniana* Walter; N America (USA).

Typical for *Urocystis simplex* are that the spore balls are restricted to mostly a single spore, and sterile cells are often absent.

Key to the *Urocystis* species of *Anemone* and *Anemonella*

1. Spore balls surrounded by a continuous layer of sterile cells 2
– Spore balls surrounded partly by a discontinuous, partly by a continuous layer of sterile cells, or sterile cells lacking 3
2. Spore balls composed of 1–20(–30) spores. ....*U. novae-zelandiae*
– Spore balls composed of 1–12 spores...........................*U. japonica*
3. Spore balls lacking sterile cells or with a few sterile cells 4
– Spore balls surrounded by an incomplete or complete layer of sterile cells 5
4. Spore balls composed of 1(–2) spores .... *U. simplex*
– Spore balls composed of 1–4(–5) spores ....*U. subnuda*
5. Spore balls composed of (0–)1–2(–3) spores; sterile cells few or lacking .... *U. anemones*
– Spore balls composed of several spores; sterile cells numerous...............6

6. Spore balls composed of 1–4(–6) spores . . . . ***U. antucensis***
– Spore balls composed of more spores 7
7. Spore balls composed of 1–6(–7) spores . . . . ***U. antipolitana***
– Spore balls composed of 1–7(–11) spores 8
8. Spore balls 16–40 µm long; spores 9.5–17 µm long . . . . ***U. sinensis***
– Spore balls 20–70 µm long; spores 13–21(–24) µm long. . . . . ***U. pseudoanemones***

New members of the genus *Gjaerumia* (*Urocystidaceae*)

The host plants of c. 180 known species of *Entyloma* are restricted to dicotyledonous host plants in 25 families (Vánky 2002:56). Two "*Entyloma*" species on *Liliaceae* s. l., *E. eremuri* and *E. muscari,* do not belong to this genus. A third species, *E. ossifragi* Rostr., on *Narthecium ossifragum* (L.) Huds., was found to represent a new genus, *Gjaerumia* R. Bauer et al. (Bauer et al. 2005:109). The other two "*Entyloma*" species on *Liliaceae* s. l. are transferred into *Gjaerumia* as:

Gjaerumia eremuri (Schwarzman) Vánky, **comb. nov.**

MycoBank: 511652

Basionym: *Entyloma eremuri* Schwarzman, Fl. spor. rast. Kazakhstana 2:266, 1960. — Type on *Eremurus tianschanicus,* Kazakhstan, Alma-Ata Region, surroundings of Alma-Ata, south slope, 18.VI.1946, S.R. Schwarzman, AA (n.v.); South Kazakhstan Region, Talasskij Alatau, road towards Djabagly, 8.VI.1951, A.N. Ustimenko, AA (n.v.). (No type designated).

Sori forming rounded-elongate, obscure, violaceous leaf spots. Spores few, embedded in the mesophyll and leaf epidermis, globose, angularly globose or ellipsoidal, 5–14 × 5–16 µm, mostly 7–9 µm in diam.; young spore walls are smooth or dotted, hyaline, 1.5–2 µm thick, when mature smoky cinnamon brown, 1–1.5 µm thick. Anamorph absent.

On *Asphodelaceae* (*Liliaceae* s. l.): *Eremurus tianschanicus* Pazij & Vved. ex Pavlov; C Asia.

Material not seen. Description taken from the original.

Gjaerumia muscari (Pass. ex J. Schröt.) Vánky, **comb. nov.**

MycoBank: 511657

Basionym: *Entyloma muscari* Pass. ex J. Schröt., in Cohn, Beitr. Biol. Pfl. 2:371, 1877, as '*Entyloma Muscari* (Passerini)'. — Type on *Muscari comosum,* Italy, Parma, G. Passerini, PARMA (n.v.).

Sori in leaves as elliptical or rhomboidal, c. 1 cm long, flat, brownish discoloured spots. Spores in the host tissue between the parenchyma cells, globose, c. 11 µm in diam., pale brown; wall thin, smooth.

On *Hyacinthaceae* (*Liliaceae* s. l.): *Muscari comosum* (L.) Mill.; Europe. Known only from the type locality.

Material not seen. Description taken from Schröter (1877:371). According to Schröter, *E. muscari* is morphologically close to *E. corydalis*. Ciferri (1924b:95) studied the type and was not completely convinced that it was an *Entyloma* species.

Key to the species of *Gjaerumia,* based on host taxonomy

1. On *Narthecium.* Spores 10–14.5(–17) µm long . . . .***G. ossifragi***
– Not on *Narthecium* 2

2. On *Eremurus.* Spores 5–16 µm long. . . . . ***G. eremuri***
– On *Muscari.* Spores c. 11 µm in diameter . . . . ***G. muscari***

An additional species of *Bauerago* (*Microbotryaceae*)

Seven species of *Bauerago* Vánky are known, parasitising host plants in *Commelinaceae*, *Cyperaceae* and *Juncaceae.* An additional species, described as *Ustilago* is transferred into this genus as:

Bauerago tinantiae (J.C. Lindq.) Vánky, **comb. nov.**

MycoBank: 511653

Basionym: *Ustilago tinantiae* J.C. Lindq., Revista Fac. Agron. Univ. Eva Perón, Ser. 3, 29:253, 1953. — Type on *Tinantia fugax*, Argentina, Salta Prov., Capital, Quebrada de San Lorenzo, alt. 1500 m, 19.III.1952, leg. H. Sleumer. Holotype LPS 22062, isotype HUV 13705!

Sori in ovaries. Spore mass chestnut-brown, powdery. Spores globose, subglobose to ellipsoidal, 9.5–11 × 9.5–13 µm, light brown; wall 1–1.5 µm thick, finely reticulate, 5–7 meshes per spore diam., areolae 1–1.5 µm wide, muri c. 0.8 µm high, in median view blunt, 17–22 on the equatorial circumference, in SEM muri and interspaces finely verruculose. Spore germination (Lindquist 1953:254) results in four-celled basidia, producing laterally and terminally ovoid basidiospores.

On *Commelinaceae: Tinantia fugax* Scheidw., *Tinantia* sp.; S America (Argentina).

Species of *Ustilago* are restricted to host plants in the *Poaceae* (see also chapter *U. duriusculae* in this paper). The recombination of *U. tinantiae* into *Bauerago* is based on spore germination, described and illustrated by Lindquist. The ascomycetous ultrastructure, observed by R. Bauer (pers. comm.) probably belongs to saprobic fungi often present in the sori of smut fungi collected in the tropics and moulded.

Sorosporium solidaginis is a *Thecaphora* (*Glomosporiaceae*)

Schofield (Bessey, Contr. Bot. Dep. Univ. Nebr. 3:48, 1892; n.v.) described *Sorosporium cuneatum*, in the flowers of *Grindelia squarrosa*, from the USA. One year later, Ellis & Everhart (1893:156) described *Sorosporium solidaginis,* in the flowers of *Solidago missouriensis,* from the USA. Two years later, Ellis & Everh. (1895:363) declared that *S. solidaginis* "is the same as *S. cuneatum* Schofield". However, a comparison of the types revealed that there are differences in the spore ball and spore morphology, which justifies treating them as two species, both within the genus *Thecaphora.*

Thecaphora solidaginis (Ellis & Everh.) Vánky, **comb. nov.**

MycoBank: 511654

Basionym: *Sorosporium solidaginis* Ellis & Everh., Proc. Acad. Nat. Sci. Philadelphia 1893:156, 1893. — Type on *Solidago missouriensis,* USA, Cansas, Rooks Co., Rockport, 28.III.1892, E. Bartholomew 531. Lectotype (designated here) BPI 179719; isolectotypes BPI 179136, BPI 179718, HUV 20819!

Sori destroying all flowers in a head, which are deformed, composed of remnants of host tissues and a reddish-brown, granular powdery mass of spore balls. Spore balls globose, subglobose, ovoid, ellipsoidal to slightly irregular, 25–40(–45) × 25–45(–50) µm, pale yellowish-brown, composed of 8 to several tens of firmly united spores which rather break than separate by hard pressure. Spores mostly subcuneiform, in surface view rounded subpolyangularly irregular, rarely elongate, 8–12 × 9.5–18 µm, radially 8–18(–20) µm long, pale yellow to pale yellowish-brown; wall of contact sides c. 0.5 µm thick, smooth, wall of the free surface 1.5–2.5(–3) µm thick, finely, moderately densely, irregularly verrucose, warts up to 1.5 µm high, isolated or 2(–3) fused, spore profile finely, irregularly wavy to serrulate.

On *Asteraceae: Solidago missouriensis* Nutt.; USA. Known only from the type collection.

Thecaphora solidaginis differs from *T. cuneata* (Schofield) G.P. Clinton (type on *Grindelia squarrosa* (Pursh) Dunal, USA), especially in the morphology of the spore balls and spores. The spore balls in *T. cuneata* are 35–60(–70) µm long, composed of 15 to several tens of spores which radially measure 12–26 µm; wall of the free surface is 2.5–4(–5) µm thick.

Ustilago stiparum is a *Sporisorium* (*Ustilaginaceae*)

Sporisorium stiparum (Speg.) Vánky, **comb. nov.**

MycoBank: 511655

Basionym: *Ustilago stiparum* Speg., Anales Mus. Nac. Buenos Aires, Ser. 3, 12:288, 1909. — *Sorosporium stiparum* (Speg.) Zundel, Mycologia 43:269, 1951. — Type on *Stipa* sp., Argentina, Mendoza, Luján de Cuyo, 1.I.1908, C. Spegazzini. Holotype LPS 3003, isotypi Herb. Hirschhorn 3003, HUV 15925!

Sori destroying the whole inflorescence, long linear, 4 cm or longer, more or less hidden by leaf sheath, at first covered by a thin, whitish peridium which breaks up in long strips exposing the dark brown, granular-powdery mass of spore balls intermixed with long columellae. Spore balls subglobose, ovoid, ellipsoidal, elongated or subpolyhedrally irregular, 30–80 × 40–90(–100) µm, dark reddish-brown to subopaque, composed of tens or hundred(?) of spores that separate by pressure. Spores globose, ovoid or subpolyhedrally irregular, 6.5–9 × 7–9.5(–10.5) µm, yellowish-brown; wall even, 0.5–0.8 µm thick, finely, densely punctate-verruculose, spore profile smooth to very finely undulate or minutely serrulate. STERILE CELLS not seen.

On *Poaceae: Stipa* sp.; Argentina. Known only from the type locality.

The fragment of the isotype, obtained from the late Dr. Elisa Hirschhorn, does not permit identification of the host plant and a description of the soral characters, which are taken from the original and Zundel (1953:74).

Synonyms

Entyloma crepidis-tectorum is identical with *E. zacintha*

Piątek (2006:165) described *Entyloma crepidis-tectorum* on the leaves of *Crepis tectorum* from Denmark. He found the spores measured (10–)13–18 (–20) × (13–)15–21(–22) µm, and unevenly, 2–5(–7) µm thick spore wall. I checked the holotype and obtained smaller values, namely 9–14.5 × 11–17 (–18.5) µm for the spores and 1–5(–5.5) µm for the wall thickness. After I discussed the problem with Dr. Piątek, I checked another sorus of the holotype and obtained (9.5–)10–15(–16) × (10.5–)12–18(–19) µm for the spores, and up to 5 µm for the spore wall thickness. Obviously, there is a certain variation in spore morphology on the same host plant, using the same method. Because the spore morphology of *E. crepidis-tectorum* is very close to that of *Entyloma zacintha* (type on *Crepis zacintha*), we came to the conclusion that it is best to treat these smuts as one species:

Entyloma zacintha Vánky, Mycotaxon 36:474, 1990.

Type on *Crepis zacintha,* Greece, Rhodos, between Agaia Isodoros and Laerma, alt. c. 200 m, 27.IV.1978, K. Vánky. Holotype HUV 7174!

Entyloma crepidis-tectorum (as "*crepidis-tectori*") Piątek, Polish Bot. J. 51:165, 2006. — Type on *Crepis tectorum,* Denmark, Yullandia, near Ryga, VII.1911, C. Ferdinandsen, BPI 174632! (syn. nov.).

SORI in leaves as rounded, thin, amphigenous, scattered or gregarious spots, 0.5–2 mm in diam., at first whitish, then yellow and finally light brown. SPORES solitary or usually densely crowded in small groups, globose, ovoid or more or less irregular by mutual pressure, 10–15 × 13–19 µm, subhyaline to pale yellowish-brown; wall two-layered, the inner layer c. 0.5 µm thick, the outer layer often unevenly thickened, 1–4(–6) µm wide, smooth. ANAMORPH not seen.

On *Asteraceae: Crepis tectorum* L., *C. zacintha* (L.) Loisel. (*Lapsana zacintha* L.; *Zacintha verrucosa* Gaertn.); Europe.

Entyloma lavrovianum is *E. hieracii*

Schwarzman (1960:297) described *Entyloma lavrovianum* on the leaves of several *Hieracium* species. Comparison of the syntypes with the lectotype of

E. hieracii did not reveal any essential difference in spore morphology. Therefore they are considered synonyms as:

Entyloma hieracii Syd. & P. Syd. ex Cif. (Ciferri, Bull. Soc. Bot. Ital. 1924:50, 1924a).

> *Entyloma hieracii* Syd. & P. Syd., Ann. Mycol. 16:244, 1918; nom. nud.. — Lectotype (design. by Vánky 1985:69) on *Hieracium murorum* L., Germany, Berlin, at Schlachtensee, VI.1897, P. Sydow, HUV 1174!; isolectotypes in Sydow, Ust. no. 143 (as '*Entyloma calendulae*').
>
> *Entyloma crepidis* Kawecka-Starmachowa, Głownie i śniecie Polski 2:173, 1939. — Type on "*Crepis praemorsa* (L.) Tausch" (= misnamed *Hieracium* sp., det. Vánky 1990:474), Ukraine, Kolomyya (formerly Poland, Kołomya), Bania Berezowska, Rokieta Mt., VI.1913, A. Wróblewski, KRAM-F 2521! (syn. by Vánky 1990:474).
>
> *Entyloma lavrovianum* Schwarzman, Fl. spor. rast. Kazakhstana 2:297, 1960. — Syntypes on *Hieracium ganeschinii* Zahn, and *H. korshinskyi* Zahn, both from Kazakhstan, Alma-Ata Region, Zailijskij Alatau, Great Alma-Ata Gorge, 19.VIII.1958, S.R. Schwarzman, AA; isosyntypes HUV 12112! & HUV 12113! (syn. nov.).

For a description see Vánky (1994:95–96).

Urocystis rechingeri and *U. radicicola* represent the same species

A study of the types of *Urocystis rechingeri* and *U. radicicola* revealed that they are identical. Both species have been collected only once, no doubt because of their hidden sori on the roots of *Ranunculus* species.

Urocystis rechingeri Petr., Sydowia 20:278, 1968 ('1966').

> Type on *Ranunculus* sp. (= *R. komarovii*, det. K.H. Rechinger), Afghanistan, Kabul, below Istalif, alt. 1850 m, 1.V.1967, K.H. Rechinger. Holotype W 9187!
>
> *Urocystis radicicola* H. Scholz & I. Scholz, Nova Hedwigia 47:69, 1988. — *Urocystis anemones* f. *radicicola* Thomas (nom. herb.). — Type on *Ranunculus arvensis*, Germany, Thüringen, Ohrdruf, 8.VI.1893, F. Thomas. Holotype HBG! (syn. nov.).

SORI as large cylindrical, fusiform or curved swellings on the upper part of the root or on the hypocotyl, 4–8 mm thick, up to 12 mm long, covered by host tissue. They have an irregularly, incompletely polycystic structure enclosing the black, semiagglutinated mass of spore balls which are liberated when the host tissues are decomposed. SPORE BALLS globose, ellipsoidal, elongated to irregular, 18–35 × 20–50 μm, reddish-brown, composed of (0–)1–4(–5) spores and an incompletely, rarely completely surrounding layer of sterile cells. SPORES globose, ellipsoidal or irregular, with one or several flattened sides, 11–16 × 13–19 μm, reddish-brown; wall even, 0.5–0.8 μm thick, apparently smooth to very finely punctate-verruculose. STERILE CELLS variable in shape and size, subglobose, ellipsoidal, elongated or irregular with slightly flattened contact sides, 5–12 × 6–15 μm, pale yellowish-brown; wall uneven, 0.5–2 μm thick, thin on the free surface, thick on the contact sides, smooth.

> On *Ranunculaceae: Ranunculus arvensis* L., *R. komarovii* Freyn; Europe (Germany), Asia (Afghanistan).

In the protologue of *Urocystis rechingeri,* the spore measurements were given as 6–11 × 10–16 µm. Under standard conditions, i.e. heated in lactophenol, I obtained larger values, as given in the description above, identical with those of *U. radicicola.* Because of the identical sori, spore morphology and host plant genus, these two names are considered synonyms.

Ustilago moehringiae is a synonym of *Microbotryum duriaeanum*

Togashi & Maki (1940:139) described *Ustilago moehringiae* in the ovaries of *Moehringia platysperma* from Japan. It was subsequently placed into the genera *Microbotryum* and *Haradaea.* A study of its type and comparison with *Microbotryum duriaeanum* could not reveal any morphological differences. Consequently, they are considered heterotypic (taxonomic) synonyms as:

Microbotryum duriaeanum (Tul. & C. Tul.) Vánky, Mycotaxon 67:43, 1998.

Ustilago duriaeana Tul. & C. Tul., Ann. Sci. Nat. Bot., Sér. 3, 7:105, 1847. — *Haradaea duriaeana* (Tul. & C. Tul.) Denchev & H.D. Shin, in Denchev et al., Mycol. Balcan. 3:72, 2006. — Type on *Cerastium glomeratum* Thuill., Algeria, Tlemcen, 30.V.1842, R.C. Durieu de Maisonneuve. Holotype in PC!

Ustilago moehringiae Togashi & Y. Maki, Ann. Phytopathol. Soc. Japan 10:139, 1940. *Microbotryum moehringiae* (Togashi & Y. Maki) Vánky, Mycotaxon 67:46, 1998. — *Haradaea moehringiae* (Togashi & Y. Maki) Denchev, in Denchev et al., Mycotaxon 98:182, 2007('2006'). — Type on *Moehringia platysperma* Maxim. (= *M. trinervia* var. *platysperma* (Maxim.) Makino), Japan, Chikuzen Prov. (= Fukuoka Pref.), Yoshikawa-mura, 7.V.1938, Y. Maki. Holotype in TNS, isotype in SAPA! (syn. nov.).

Sori in ovules, filling the capsules with at first agglutinated, later powdery, dark purplish-brown spore masses. Infection systemic, all capsules of an infected plant being affected. Spores globose, subglobose to ovoid, 11–15 × 12–17 µm, light to medium purplish-brown, reticulate, 4–8 meshes per spore diam., muri 1–2(–2.5) µm high, 16–22 on the spore circumference; interspaces in SEM with a smooth or slightly roughened tubercle.

On *Caryophyllaceae* (subfam. *Alsinoideae*): *Arenaria, Cerastium* and *Moehringia* species, Europe, N & NE Africa, Asia, N America.

Lectotype

Entyloma lobeliae Farl., Bot. Gaz. (Crawfordsville) 8:275, 1883.

Lectotype on *Lobelia inflata* L., USA, Maine, Gilead, VIII.1882, W.G. Farlow, (designated here) BPI 175796.

Sori on the leaves forming rounded or polyangular, flat, amphigenous spots, 1–10 mm in diam., first whitish, later pale yellowish-brown. Spores globose, subglobose, ellipsoidal or slightly irregular, 8–12 × 9–14 µm, subhyaline to pale yellow; wall even, 1–1.5 µm thick, smooth. Anamorph present.

On *Lobeliaceae: Lobelia cliffortiana* L., *L. inflata* L., *L. laxiflora* Kunth, *L. purpurascens* R.Br., *L. spicata* Lam.; N & C America.

Entyloma lobeliae was described by Farlow, collected on *Lobelia inflata,* from USA, Maine, Gilead, on August 18882. No type is preserved in FH. A neotype for it was designated by Piepenbring (2003:211) on "*Lobelia* sp., USA, N.H., Shelburne, 1883, FH". An isotype of *E. lobeliae* is preserved in BPI 175796. According to Article 9.17(a) of the ICBN Vienna, the isotype supersedes the designated neotype, which is not mentioned in the protologue.

Doassansiopsis guangdongensis, an unusual species

Recently, in addition to the 13 known species of *Doassansiopsis,* (*Urocystidales, Doassansiopsidaceae*) a new species, *D. guangdongensis* S.H. He & L. Guo (He & Guo 2007:101) was described on *Alisma* sp. from China. The genus *Doassansiopsis* is characterised by permanent spore balls, embedded in the host tissue of aquatic or paludal plants. The spore balls are composed of a central mass of parenchymatous sterile cells, surrounded by spores and an outer cortical layer of sterile cells. There is another group of 36 similar smut fungi, the "*Doassansia*" group, classified in 11 genera within the *Doassansiales, Doassansiaceae.* These genera differ from each other by the composition and arrangement of the spores, sterile cells and/or hyphae in the balls (comp. Vánky 2002:9, Pl. I, Figs. 1–11, and Vánky & Shivas 2006:16, Figs. 3–6). The composition and structure of the spore balls can be studied best in embedded, sectioned and stained balls, because the poorly pigmented and often very similar spores and sterile cells are difficult to recognise and differentiate in hand-cut, not properly stained balls. Study of the isotype of *D. guangdongensis* revealed another structure of the spore balls than given in the protologue. In the original description, the pigmented, outer layer of sterile, cortical cells were mistaken for spores, host plant cells surrounding the balls as sterile cells, and the spores as a part of the central mass of sterile cells. A revised description of this smut is:

Doassansiopsis guangdongensis S.H. He & L. Guo, Mycotaxon 101:2, 2007, emend. Vánky

Type on *Sagittaria* sp., China, Guangdong (no further data). Holotype HMAS 17625, isotype HUV 21445!

Sori on the leaves forming yellowish brown, flat spots, from 1–2 to 10 mm in diameter or larger by confluence, with spore balls embedded in the host tissue as densely situated, pale brown dots. Spore balls (Figs. 21, 22) globose, subglobose, ellipsoidal, elongated or slightly irregular, with flattened sides, c. 80–200 × 100–320 µm, pale olivaceous brown, composed of a central mass of empty, parenchymatous, sterile cells, surrounded by 1–3(–4), irregular, often interrupted layers of spores, and a thick, well-developed cortical layer of empty, thick-walled, pigmented sterile cells. Spores subglobose, ellipsoidal or rounded irregular with slightly flattened contact sides, 5–9 × 5.5–10.5

µm, pale olivaceous brown; wall even, 0.5–0.7 µm thick, smooth, content homogenous. Sterile cells globoid or elongated, usually subpolyhedrally or polyhedrally irregular, 5–12.5 × 5.5–20 µm, pale olivaceous brown tinted; wall even, 0.2–0.3 µm thick. Cortical cells subglobose, ellipsoidal, rounded irregular with slightly flattened contact sides, tangentially or radially elongated or isodiametric, (5–)6–10.5 × (5–)7–13.5(–16) µm, medium dark olivaceous brown; wall uneven, 0.7–1.5 µm thick, smooth.

On *Alismataceae*: *Sagittaria* sp.; E Asia. Known only from the type collection.

D. guangdongensis is closest to *D. intermedia* (Setch.) Vánky (type on *Sagittaria latifolia* Willd., USA), in which there are 3–6 compact layers of spores in the balls.

A tentative key to the genera of smut fungi (*Ustilaginomycotina* p.p., and *Microbotryales*) based on selected characters and on host plant taxonomy

During the last few decades numerous genera of smut fungi have been described, many as a result of the application of ultrastructural and molecular phylogenetic methods. The Illustrated Genera of Smut Fungi (Vánky 2002) listed 77 genera. Today 91 genera are known. and a key is given to these genera below. For detailed descriptions and illustrations see Vánky (2002), and for the new genera consult the mycological literature after 2002.

1. On *Pteridophyta* 2
– Not on *Pteridophyta* 3

2. On *Selaginellaceae*; sori as black spots on leaves or stems; spores single, blackish-brown, embedded in the host tissue. . . . . **Melaniella**
– On *Osmundaceae*; sori external on hypertrophied, deformed leaves, cinnamon brown; spores produced in chains . . . .**Exoteliospora**

3. On *Gymnospermae* (*Araucariaceae*); sori in the inflorescence on the surface of host tissue; one to several spores enclosed by a foveolate coat. . . . . **Uleiella**
– On *Angiospermae;* spores not enclosed by a foveolate coat 4

4. On *Eriocaulaceae* (seeds) 5
– Not on *Eriocaulaceae* 7

5. Spores single . . . . **Eriocaulago**
– Spores in spore balls 6

6. Spore balls mixed with sterile cells and covered by a cortex. . . . . **Eriomoeszia**
– Spore balls without sterile cells and cortex . . . . **Eriosporium**

7. Two different kinds of spores present in the same sorus. 8
– Spores of the same kind (but conidia or sterile cells may be present). 9

8. Small, hyaline, single spores mixed with large, pigmented spore balls; spore mass grey; on *Cyperaceae* and *Juncaceae*. . . . . **Heterotolyposporium**

– Thin-walled, ellipsoidal, ridged spores and thick-walled, globose, tuberculate spores of the same pale colour present; spore mass butter-coloured; in flowers of *Polygonaceae*. . . . . ***Zundeliomyces***

9. Spores mixed with groups of Y-shaped conidia; in ovaries of *Poaceae* . . . . ***Conidiosporomyces***

– Spores not mixed with such conidia 10

10. Spores single 11 (60, 76, 79, 80, 83, 84, 91, 94)

– Spores in pairs or in balls, or spores several celled (sometimes in groups or single) 57 (17, 39)

– Spores firmly agglutinated in indefinite masses in the leaves of *Convolvulaceae* . . . . ***Georgefischeria***

11. Spore wall separated into two layers by a hyaline, gelatinous mass 12

– Spore wall not separated into two layers 13

12. Spore wall completely separated into two membranes; the outer membrane ruptures readily permitting the true spore to pass freely; on *Cyperaceae* . . . . ***Kuntzeomyces***

– Spore wall separated only in two opposite sides, forming light-coloured polar caps; on dicots (various families) . . . . ***Yelsemia***

13. Spore mass powdery at maturity, in various parts of the host 14

– Spore mass semi-powdery to agglutinated, black; on *Cyperaceae* and *Juncaceae* 31

– Spore mass not powdery at maturity, spores embedded in the host tissue. 40

14. Sori forming pustular galls on the stems of *Tiliaceae* . . . . ***Pericladium***

– Sori not so 15

15. Sori in the flowers of *Hyacinthaceae* (*Liliaceae* s.lat.) . . . . ***Antherospora***

– Sori not so 16

16. Spores large, mainly (10–)15–35 µm 17

– Spores small to medium-sized, mainly 5–15 µm 23

17. Sori external, forming crusts on leaves of *Cyperaceae;* spores single or in balls . . . . ***Orphanomyces***

– Sori not external, forming powdery spore masses in the host tissues 18

18. Sori on leaves forming pustules or swellings; on *Liliaceae* s.str. . . . . ***Vankya***

– Sori in ovaries; not on *Liliaceae* 19

19. Spore mass golden- to rusty brown; on *Cyperaceae* and *Juncaceae* . . . . . ***Bauerago***

– Spore mass pale or dark reddish or blackish-brown; on *Poaceae* 20

20. Spores elongate, foveolate, with a conspicuous hyaline appendage . . . . . ***Neovossia***

– Spores globoid, otherwise sculptured, appendage lacking or short, papilla-like 21

21. Spores with a dark, pigmented ring; basidia reduced to the spores . . . . ***Oberwinkleria***

– Spores without a dark, pigmented ring; basidia not reduced to the spores 22

22. Spores peculiarly ridged; basidiospores 1–2, ballistosporic .... ***Ingoldiomyces***
– Spores not peculiarly ridged (usually reticulate, verrucose, tuberculate, with subpyramidal warts or spines, rarely smooth); basidiospores several, not ballistosporic .... ***Tilletia***

23(16). Sori with sterile fungal chains or filaments .... .24
– Sori without sterile chains or filaments .... .26

24. Sori with sterile fungal chains; on *Poaceae* .... ***Franzpetrakia***
– Sori with filaments; not on *Poaceae* .... .25

25. Filaments of uncertain origin; spores violet tinted, produced in cavities in the flowers or in tumours on the stems of *Polygonaceae* .... ***Liroa***
– Filaments of fungal origin; spores not violet tinted, in flowers of *Cyperaceae* .... ***Farysia***

26(23). On dicots.. .27
– On monocots (*Poaceae*).. .29

27. On *Euphorbiaceae* (in seeds of *Euphorbia*); spore mass brown, without violet tint .... ***Ahmadiago***
– Not on *Euphorbiaceae;* spore mass light to dark purplish-brown, spores violet tinted.. .28

28. Peridium and columella present; spores at first catenate; on *Polygonaceae* .... ***Sphacelotheca***
– Peridium and columella absent; spores not catenate; on various families .... ***Microbotryum***

29(26). Sori naked surrounding stems or floral axis; spores usually small, <8 µm .... ***Tranzscheliella***
– Sori not so; spores usually larger .... .30

30. Spores single or in groups of pseudo spore balls, mixed with sterile cells .... ***Macalpinomyces***
– Spores single, not mixed with sterile cells, ... ***Ustilago***

31(13). Sori as onion-like swellings at the base of culms and basal leaves of *Eleocharis* .... ***Parvulago***
– Sori not so .... .32

32. Sori around the nuts of *Cyperaceae;* spores single; basidium 2-celled .... .33
– Sori in different organs of the host plants in *Cyperaceae* or *Juncaceae;* spores single, rarely in balls, variously sculptured; basidium 4-celled .... .34

33. Spores with a dark equatorial band and two light polar areas .... ***Planetella***
– Spores not so.. .... ***Anthracoidea***

34. Sori usually with sterile stroma surrounding internodes of the culms or floral pedicels, rarely the apex of sterile spikelets.................................. .35
– Sori not so .... .36

35. Infection systemic, host plants sterile .... ***Leucocintractia***

– Infection localised, host plants not sterile .... ***Cintractia***

36. Sori in some spikelets of an inflorescence 37

– Sori in all spikelets (or groups of spikelets) of an inflorescence 38

37. Sori with a sac-like peridium; spores powdery, mixed with long, hyphal cells .... ***Trichocintractia***

– Sori without sac-like peridium; spores agglutinated, mixed with gelatinised hyphae .... ***Pilocintractia***

38. On *Juncaceae;* spores single .... ***Stegocintractia***

– On *Cyperaceae* 39

39. On *Scirpus;* spores single .... ***Portalia***

– On *Rhynchospora, Bulbostylis, Cyperus, Scleria;* spores single or in balls .... ***Ustanciosporium***

40(13). Sori forming irregular galls 41

– Sori forming spots, sometimes pustules or rarely swellings or crusts on leaves and stems 44

41. Galls multilocular; spores embedded in a gelatinous mass; on *Polygonaceae* .... ***Melanopsichium***

– Galls not multilocular, spores not so; not on *Polygonaceae* 42

42. Sori as witches' brooms on leaves or inflorescence of *Cyperaceae* (*Mapanioideae*) with bundles of cylindrical branches; spore mass black; spores not intracellular .... ***Cintractiella***

– Sori as galls on roots (not *Mapanioideae*); spore mass pale; spores intracellular 43

43. Sori on *Cyperaceae* and *Juncaceae* .... ***Entorrhiza***

– Sori on dicotyledonous plants (in *Aizoaceae, Molluginaceae, Portulacaceae*) .... ***Talbotiomyces***

44(40). Spores pigmented, olivaceous or blackish-brown 45

– Spores pale coloured 53

45. Sori on dicotyledonous host plants as dark spots, pustules or swellings on leaves, stems or roots (basidium of *Tilletia*-type) 49

– Sori on monocots, or known only from culture 46

46. Sori on *Ruppiaceae* .... ***Flamingomyces***

– Sori not on *Ruppiaceae* 47

47. Sori on *Poaceae* and *Cyperaceae* 50

– Sori not on *Poaceae* and *Cyperaceae* (forming dark leaf spots) 48

48. On *Araceae*; septal pore simple with two membrane caps and two inner plates .... ***Melanustilospora***

– On *Asphodeliaceae, Hyacinthaceae, Melanthiaceae* (*Liliaceae* s.lat.; *Eremurus, Muscari, Narthecium*); septal pore a dolipore .... ***Gjaerumia***

49(45). Sori as dark spots on leaves of *Fabaceae;* septal pore a dolipore, pore caps lacking .... ***Erratomyces***
– Sori on various dicots, not on *Fabaceae,* forming dark leaf spots, pustules or swellings; septal pore simple with two membrane caps, inner plates lacking .... ***Melanotaenium***

50. Basidia 4-celled, phragmobasidia with ballistosporic basidiospores on lateral sterigmata.......... 51
– Basidia 1-celled, holobasidia with apical basidiospores 52

51. Sori on *Poaceae* as black leaf spots; spores smooth .... ***Phragmotaenium***
– Known only from culture; spores echinulate .... ***Tilletiaria***

52. Sori on *Poaceae* and *Cyperaceae* as dark spots, crusts or powdery cover on leaves, leaf sheaths and stems; ballistospores present .... ***Jamesdicksonia***
– Sori on *Poaceae* as dark leaf spots; spores embedded in the leaf tissue; no ballistospores.......... ***Eballistra***

53(44). Spore mass powdery, yellowish or pale reddish-brown .... (a few) ***Tilletia***
– Spore mass not powdery, embedded in the host tissue, subhyaline or pale yellowish-brown 54

54. Germination of *Ustilago*-type; on monocots (*Poaceae*) .... ***Ustilentyloma***
– Germination of *Tilletia*-type; on dicots.......... 55

55. On aquatic plants 56
– On terrestrial plants .... ***Entyloma***

56. Spores lemon-shaped, with a papilla and an appendage. .... ***Rhamphospora***
– Spores globose to broadly ellipsoidal, without papilla and appendage ***Doassinga***

57(10). Spores in pairs (rarely the pairs in balls) 58
– Spores in balls or spores several-celled 60

58. Spore germination of *Mycosyrinx*-type; on *Vitaceae* .... ***Mycosyrinx***
– Spore germination of *Ustilago*-type; not on *Vitaceae*.......... 59

59. Sori hypertrophied; spores produced in cavities of the host tissue; basidiospores brown; on *Sterculiaceae* .... ***Geminago***
– Sori not hypertrophied; spores produced intraepidermally; basidiospores hyaline; on *Cyperaceae*.......... ***Schizonella***

60(57). Spores one- to several-celled; on *Araliaceae* .... ***Mundkurella***
– Spores in ephemeral or permanent balls; not on *Araliaceae*.......... 61

61. Sori not bursting at maturity, not dusty; spore balls pale, embedded in the host tissue of aquatic or paludal plants 62
– Sori bursting at maturity, usually granular-dusty; spore balls pigmented 72

62. Spore balls without cortex.......... 63
– Spore balls with cortex 65

63. Spore balls consisting of parenchymatous fungal tissue of sterile cells in which the spores are scattered .... ***Burrillia***
– No parenchymatous sterile cells in the spore balls.......... 64

64. Spore balls loose, friable, consisting of branched hyphae in which the spores are scattered . . . . ***Nannfeldtiomyces***
– Spore balls not friable, composed of spores only . . . . ***Entylomaster***

65. Cortex of firmly united spores 66
– Cortex of sterile cells 67

66. Central part of the spore balls consisting of a network of branched hyphae ***Tracya***
– Central part of the spore balls consisting of parenchymatous fungal tissue . . . . ***Pseudotracya***

67. Spore balls lobed and also containing cavities . . . . ***Narasimhania***
– Spore balls not lobed, compact, without cavities 68

68. Central part of the spore balls composed of hyphae; spores situated between these and the cortex . . . . ***Pseudodoassansia***
– Central part of the spore balls not composed of hyphae. 69

69. Central part of the spore balls composed of parenchymatous sterile cells only; spores situated between these and the cortex . . . . ***Doassansiopsis***
– Central part of the spore balls composed of spores or also of sterile cells 70

70. Central part of the spore balls composed of spores only 71
– Central part of the spore balls composed of spores scattered in a network of sterile fungal cells . . . . ***Pseudodermatosorus***

71. Cortical cells of one kind, not ornamented. . . . .***Doassansia***
– Cortical cells of two kinds: external, small, not ornamented, and internal, larger, ornamented on their inner surface. . . . . ***Heterodoassansia***

72(61). Spore balls formed by spores and sterile cells 73
– Spore balls formed by spores only 76

73. The outer layer of the spore balls is formed by sterile cells. 74
– The outer layer of the spore balls is not formed by sterile cells 75

74. Spores and sterile cells reticulate; the reticulum between the spores appears as small, empty cells; in seeds of *Cyperaceae* . . . . ***Dermatosorus***
– Spores and sterile cells smooth or nearly so; in different organs of host plants of various families . . . .***Urocystis***

75. Sterile cells filling the spore balls, surrounded by a cortex of dark spores; on *Cyperaceae* . . . . ***Testicularia***
– Sterile cells scattered between the spores; cortex lacking; on *Poaceae* . . . . ***Moesziomyces***

76(72). Between pigmented spore balls and some single spores numerous small, hyaline, solitary spores present; spore mass grey coloured; on *Cyperaceae* and *Juncaceae* . . . . ***Heterotolyposporium***
– No hyaline spores between the spore balls; spore mass of another colour 77

77. Spore mass and spores light or dark yellowish, orange- or reddish-brown 78
– Spore mass and spores dark, blackish-brown to black 84

78. Sterile cells absent between the spore balls 79
– Sterile cells usually present between the true or pseudo spore balls; on *Poaceae* . . 82

79. On dicots; spore germination of *Thecaphora*-type or also with holobasidia . . . . ***Thecaphora***
– On monocots; spore germination of *Ustilago*-type, with phragmobasidia 80

80. Spores brown; on *Poaceae* (spore balls may be ephemeral; sterile cells may be present) . . . . ***Sporisorium***
– Spores golden-yellow; on *Poaceae* or *Cyperaceae* 81

81. Sori on stems of *Poaceae* (spore balls persistent) . . . . ***Fulvisporium***
– Sori in spikelets of *Cyperaceae* (spore balls persistent, loose or spores single) . . . . ***Aurantiosporium***

82(78). Two different kinds of sterile cells present between the spore balls; sori divided into compartments . . . . ***Anomalomyces***
– Only one kind of sterile cells present (or also lacking); sori not divided into compartments 83

83. Spores in true (often ephemeral) spore balls; columella present . . . . ***Sporisorium***
– Spores in pseudo spore balls or spores single; columella absent or rudimental . . . . ***Macalpinomyces***

84(77). Fascicles of fungal sterile filaments between the spore balls and spores present; exospore typically cracked, scaly; on *Cyperaceae* (*Gahnia*) . . . . ***Farysporium***
– Fascicles of fungal sterile filaments absent; exospore not so 85

85. On *Restionaceae* s.lat. 86
– Not on *Restionaceae* 87

86. Sori as bullate striae on the culms of sterile plants; spores extremely varying in shape and size . . . . ***Websdanea***
– Sori in the seeds; spores not so . . . . ***Restiosporium***

87. On *Centrolepidaceae* (seeds of *Centrolepis*) . . . . ***Centrolepidosporium***
– Not on *Centrolepidaceae* 88

88. Sori in the flowers of *Agavaceae* (*Liliaceae* s.lat.) . . . . ***Floromyces***
– Sori not so 89

89. Sori in the leaf-veins of *Rosaceae;* spore germination of *Ustacystis*-type **Ustacystis**
– Sori and spore germination not so; not on *Rosaceae* 90

90. Sori on the surface of young leaves of *Cyperaceae* (*Carex*) forming black cover; spores foveolate or reticulate, in balls or single; basidium short with one, long, septate basidiospore . . . . ***Orphanomyces***
– Sori, spores and basidia not so 91

91. Sori on the surface of leaves and inflorescence of *Dracaenaceae* (*Liliaceae* s. lat.; *Nolina*); spores smooth, in balls or single; basidium bifurcate, with two basidiospores . . . . ***Clintamra***
– Sori, spores and basidia not so 92

92. Sori on the surface, or in the spikelets of host plants in the *Juncaceae* and *Cyperaceae* . . . . ***Tolyposporium***
– Sori not so 93

93. Sori on the inner, adaxial side of the leaf sheaths of *Poaceae;* spore wall extremely varying in thickness; ballisto-basidiospores produced on phragmobasidia present . . . . ***Tolyposporella***
– Sori in the flowers of *Cyperaceae;* spore wall not so; no ballisto-basidiospores produced 94

94. Spores in firm spore balls; spores deformed, usually wedge-shaped, smooth on the contact sides, verrucose on the free surface . . . .***Moreaua***
– Spores in balls or single, usually rounded, not much deformed but slightly flattened, with two, small, hyaline appendage on the flattened sides, commonly foveolate . . . .***Ustanciosporium***

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Psilocybe (*Basidiomycotina, Agaricales, Strophariaceae*) in Canada, with a special review of species from British Columbia

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Abstract — Historically, 28 species of *Psilocybe* have been reported from Canada, with the oldest report dating back to 1913. Of these, *P. corneipes* has been transferred to *Mythicomyces corneipes*, two (*P. rhombispora, P. subfimetaria*) have been synonymized under earlier names, *P. callosa* has been redetermined as another species, and two reports (*P. merdaria, P. pratensis*) are doubtful. With the report of three new records from British Columbia (*P. angustispora, P. apelliculosa, P. subcoprophila*), the total number of verified *Psilocybe* species recognized in Canada now stands at 24, with the highest number of taxa concentrated in British Columbia. Eleven of the known taxa of *Psilocybe* in Canada are hallucinogenic, with *P. quebecensis* the only endemic species, *P. semilanceata* common throughout the country Canada, and *P. pelliculosa* apparently widespread in British Columbia.

Key words — hallucinogenic mushrooms, North America

Introduction

Redhead (1997), who documented macrofungal inventory in British Columbia, observed, "Our knowledge is most incomplete for macrofungi: less than 1% of the macrofungi flora of British Columbia have been examined in systematic studies." This observation might also reflect what was known about *Psilocybe* for most of Canada. MacKay (1913) and Davidson (1930) were the first to report *Psilocybe* for the country. MacKay (1913) discussed a case of intoxication in children in Nova Scotia; the mushrooms in question were sent to Peck, who identified them as *Panaeolus* (now *Psilocybe*) *semilanceata* (Guzmán 1983, Redhead 1989). Davidson (1930) reported *P. subviscida* from among agarics collected in Vancouver, BC.

Not until the 1950–70's did interest in Canadian *Psilocybe* species begin to build, following the discovery of hallucinogenic mushrooms in Mexico, Canada, and the U.S.A. (Singer & Smith 1958, Ola'h & Heim 1967, Robinson 1975, Guzmán et al. 1977). The earliest report of recreational use of hallucinogenic *Psilocybe* in Canada was in 1965, when the Royal Canadian Mounted Police confiscated mushrooms — later identified as *P. semilanceata* by A.H. Smith — from students at the University of British Columbia (Benedict et al. 1967, Pollock 1978, Davis 1981). Groves (1962) did not include a single *Psilocybe* description in his comprehensive Mushrooms of Canada, although he did cite *P. semilanceata* "type" species for the genus; Redhead (1979, 1981) subsequently added a description and an illustration of *P. semilanceata* to the fourth and fifth editions of Groves' book. Recently, Nugent & Saville (2004) sequenced DNA from several species from Canada; included among the species tested was a culture obtained from a confiscated collection of *P. cubensis*, a tropical species that is not found in the wild in Canada.

We discuss here all known species of *Psilocybe* reported in Canada, and present data from examinations of *Psilocybe* collections made by the second author (Kroeger) in British Columbia as well of others from the UBC Herbarium.

Materials and methods

Bibliographic references on *Psilocybe* in Canada were extensively reviewed and *Psilocybe* collections in the Kroeger personal and UBC herbaria were studied. Microscopic observations were made of tissues hand sectioned from basidiomata, mounted in 5% KOH, 1% Congo red and 5% NH_4OH, with at least 25 measurements made for each microstructure. All drawings were made with the aid of a light microscope drawing tube. Basidiospore sizes are stated as length and width in face-view, and thickness in side-view.

Results

From 1913 (MacKay 1913) to the present, 28 species of *Psilocybe* have been reported from Canada (Table 1). Verification of these reports required (and still require) re-examination of herbarium collections because some records may represent misidentifications. *Psilocybe corneipes* (Smith 1938, 1949) was excluded because it belongs to the genus *Mythicomyces* Redhead & A.H. Sm. (Redhead & Smith 1986). Collections reported as *P. rhombispora* and *P. subfimetaria* belong under the synonymous names *P. phyllogena* and *P. sierrae*, respectively. Collections reported as *P. callosa* have been redetermined as *P. strictipes*, and *P. physaloides* probably should be referred to *P. subviscida* var. *subviscida* (Guzmán 1995, Noordeloos 2001). The reports of *P. merdaria* (Lincoff 1981, Stamets 1996) need to be reviewed due to the confusion and the lack of herbarium material; they probably also represent another species. Three species are reported for the first time from Canada, as discussed below (see Table 1).

We now recognize 24 species of *Psilocybe* for Canada, which represents 11% of the 227 species reported worldwide by Guzmán (2005). There are 11 hallucinogenic species found in Canada, which represent 8% of the 144 accepted by Guzmán (2005) in the world. Most *Psilocybe* species known from Canada occur in British Columbia, with only a few reported from eastern Canada, mainly in Ontario (TABLE 1). Of the hallucinogenic species in Canada, *P. quebecensis* appears to be the only endemic and *P. semilanceata* the most widespread in Canada; *P. pelliculosa* is commonly reported in British Columbia.

TABLE 1. Known species and new records of *Psilocybe* in Canada [1]

P. acadiensis* A.H. Sm., J. Elisha Mitchell Sci. Soc. 62: 192, 1946. **NS (Smith & Hesler 1946, Guzmán 1983).

****P. angustispora*** A.H. Sm., J. Elisha Mitchell Sci. Soc. 62: 193, 1946. **BC.**

****P. apelliculosa*** P.D. Orton, Notes R. Bot. Gard. Edinb. 29: 118, 1969. **BC.**

**P. atrobrunnea* (Lasch) Gillet, Les Hyménomycètes, p. 586, 1878 (Redhead 1979, 1981, Stamets 1996; without locality).

P. baeocystis Singer & A.H. Sm., Mycologia 50: 141, 1958. **BC** (Robinson 1975, Guzmán et al. 1977, 1998, Repke et al. 1977, Stamets 1978, Guzmán 1983, Ammirati et al. 1985, Redhead 1997).

P. bulbosa* (Peck) A.H. Sm., Mycologia 40: 694, 1948. **ON (Redhead 1984).

P. caerulipes (Peck) Sacc., Syll. Fung. 5: 1051, 1887. **ON** (Singer & Smith 1958, Robinson 1975, Ammirati et al. 1985, Guzmán et al. 1998).

[*P. callosa* (Fr.) Quél., sensu Guzmán 1983 (see *P. strictipes*)]

P. coprophila* (Bull.) P. Kumm., Führ. Pilzk., p. 71, 1871, **BC, **QC** (Guzmán 1983).

[**P. corneipes* (Fr.) P. Karst., sensu A.H. Smith (1938, 1948, 1949) = *Mythicomyces corneipes* (Fr.) Redhead & A.H. Sm., Can. J. Bot. 64: 643, 1986. **BC**, **NS**, **ON** (Smith 1938, 1948, 1949, Stamets 1978, Redhead & Smith 1986, Huhtinen & Vauras 1992)].

P. cyanescens Wakef., Trans. British Myc. Soc. 29: 141, 1946. **BC** (Robinson 1975, Guzmán 1978, 1983; Stamets 1978, 1996, Lincoff 1981, Ammirati et al. 1985, Redhead 1997, Guzmán et al. 1998).

P. cyanofibrillosa Guzmán & Stamets, Mycotaxon 11: 477, 1980. **BC** (Stamets 1996, Guzmán et al. 1998).

P. fimetaria (P.D. Orton) Watling, Lloydia 30: 150, 1967. **BC**, **NB** (Guzmán 1983, Stamets 1996, Redhead 1997, Guzmán et al. 1998).

P. inquilina* (Fr.) Bres., Icon. Mycol. 18, pl. 863, 1931. **BC (Kroeger 1989, Redhead 1997).

[**P. merdaria* (Fr.) Ricken, Blätterpilze, p. 251, 1912. **BC**, **QC** (Lincoff 1981, Guzmán 1983, Stamets 1996)].

**P. montana* (Pers.) P. Kumm., Führ. Pilzk, p. 71, 1871, without locality (Redhead 1979, 1981).

P. pelliculosa (A.H. Sm.) Singer & A.H. Sm., Mycologia 50: 280, 1958. **BC** (Robinson 1975, Guzmán et al. 1977, 1998, Repke et al. 1977, Redhead 1979, 1981, 1997, Lincoff 1981, Guzmán 1983, Ammirati et al. 1985).

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[1] [information in brackets] = excluded or questionable records; * = non-hallucinogenic species; **bold-face** = new records

Canadian provinces (abbreviations): Alberta (**AB**); British Columbia (**BC**); Manitoba (**MB**); New Brunswick (**NB**); Newfoundland (**NL**); Nova Scotia (**NS**); Ontario (**ON**); Prince Edward Island (**PE**); Quebec (**QC**); Saskatchewan (**SK**).

Table 1, concluded

*P. *phyllogena* (Peck) Peck, Bull. N.Y. State Mus. 157: 99, 1912. **BC**, **NB** (Guzmán 1983, Redhead 1997, as *P. rhombispora*).

[**P. physaloides* (Bull.) Quél., Mem. Soc. Émul. Montbéliard (Ser. 2) 5: 256, 1872, nomen dubium; see discussion of *P. subviscida* var. *subviscida*.]

[**P.* aff. *pratensis* P.D. Orton, Notes R. Bot. Gard. Edinb. 29: 120, 1969. **BC** (Kroeger 1989, Redhead 1997)].

P. quebecensis Ola'h & R. Heim, Compt. Rend. Hebd. Séances Acad. Sci. 264: 1601, 1967. **QC** (Ola'h 1967, 1973, Ola'h & Heim 1967, Guzmán 1978, 1983; Stamets 1978, 1996, Chilton 1978, Guzmán et al. 1998).

[**P. rhombispora* (Britzelm.) Sacc., Syll. Fung. 11: 72, 1895, a synonym of *P. phyllogena*].

P. sabulosa* Peck, Bull. Torrey Bot. Club 24: 144, 1897. **BC (Redhead 1997).

P. semilanceata (Fr.) P. Kumm., Führ. Pilzk., p. 71, 1871. **BC**, **NB**, **NL**, **NS**, **PE**, **QC** (Groves 1962, Heim et al. 1966?, Ola'h 1967, Robinson 1975, Guzmán et al. 1977, 1998; Repke et al. 1977, Weil 1977, Stamets 1978, 1996, Lincoff 1981, Guzmán 1983, Ammirati et al. 1985, Redhead 1979, 1981, 1989, 1997, Schalkwijk-Barendsen 1991a, b, Turner & Szczawinski 1991).

P. sierrae* Singer, Beih. Nova Hedwigia 29: 240, 1969. **BC (Guzmán & Smith 1978, Guzmán 1983, 1995, Stamets 1996, Redhead 1997, Guzmán et al. 1998; some as *P. subfimetaria*).

P. silvatica (Peck) Singer & A.H. Sm., Mycologia 50: 277, 1958. **ON** (Singer & Smith 1958, Robinson 1975, Stamets 1978, 1996, Redhead 1979, 1981, Guzmán et al. 1998).

P. strictipes Singer & A.H. Sm., Mycologia 50: 141, 1958 [= *P. callosa* (Fr.) Quél., sensu Guzmán 1983]. **BC** (Robinson 1975, Guzmán et al. 1977, 1998, Guzmán 1983, 1995, Ammirati et al. 1985, Stamets 1996, Redhead 1997).

P. stuntzii Guzmán & J. Ott, Mycologia 68: 1261, 1977. **BC** (Guzmán & Ott, 1977, Guzmán et al. 1977, 1998, Repke et al. 1977, Stamets 1978, 1986, Guzmán 1983, Ammirati et al. 1985, Redhead 1997).

****P. subcoprophila*** (Britzelm.) Sacc., Syll. Fung. 11: 72, 1895. **BC.**

[**P. subfimetaria* Guzmán & A.H. Sm., Mycotaxon 7: 518, 1978, a synonym of *P. sierrae*)]

P. subviscida* (Peck) Kauffman var. *subviscida*, Agar. Mich., p. 275, 1918. **BC, **NB** (Davidson 1930, Lowe 1969; Guzmán 1983, Stamets 1996, Redhead 1997; some as *P. physaloides*).

Discussion of British Columbian *Psilocybe* collections

Psilocybe angustispora (Figs. 1–2)

Specimen studied. **BRITISH COLUMBIA**, **Saturna Island**, on deer pellets, September 18, 1983, Kroeger 590 (UBC-2730).

Basidiospores 11–14 × 6–7 × 6–7 µm, subellipsoid, thick-walled, wall 1–1.5 µm thick, with a broad germ pore; pleurocystidia absent; cheilocystidia 30–42 × (6–)7–10 µm, lageniform.

Comments: *Psilocybe angustispora* is close to *P. subcoprophila*, but the latter has longer spores — (13–)14–18(–22) µm (Guzmán 1983).

This species was known only from the U.S.A. (Colorado, Idaho, Oregon and Washington) (Smith & Hesler 1946, Guzmán 1983, Stamets 1996). It is defined by its mycenoid basidiomata and its peculiar habitat on dung, mainly pellets of deer and elk, but also grows on horse dung, in temperate forests or alpine meadows. This report is the first record for Canada.

Psilocybe apelliculosa (Figs. 3–6)

Specimens studied. **BRITISH COLUMBIA**, **Vancouver**, Sept. 22, 1981, Kroeger 01; Botanical Gardens of the University of British Columbia, Asian Gardens, September 12, 1985, Kroeger 868, 869; September 19, 1987, Kroeger 1251. University of British Columbia campus, September 18, 1997, Kroeger 2063; September 21, 1997, 2064, 2065 (all in Kroeger Herbarium, UBC and XAL; 01, 868, 869 & 1251 also in DAOM).

Pileus (6–)10–20 mm diam, convex to subumbonate, finally plane, slightly viscid to dry, hygrophanous, with silky and grayish fibrils, dark cinnamon-brown or dark reddish-brown to pale reddish-brown or pale orangish on the margin. Lamellae adnate to short decurrent, grayish when young to brownish-gray or dark brown-violaceous when mature, edges whitish and subfloccose or denticulate, finally concolorous or slightly paler. Stipe (17–)30–40 × 1.5–2.5 mm, equal or slightly thickened at apex, hollow, often flexuous, base subfloccose, often extending into the substrate and covered with white tomentum; surface dark gray-brown to ochraceous-honey, finally reddish-brown, sometimes covered with floccose white scales. Veil cortinaceous, fugacious, remains as adpressed pale yellowish fibrils in the upper part of the stipe and in the pileus margin. Basidiospores (5–)5.5–7(–8) × 4–5 × 3.5–4.5 µm, subrhomboid or subellipsoid in face-view, subellipsoid in side-view, thin-walled, wall up to 0.5 µm thick, yellowish-brown. Pleurocystidia absent. Cheilocystidia (13.5–)18–31 × (6–)8–12(–14) µm, utriform, broadly utriform or sublageniform, hyaline. Pileipellis with prostrated hyaline hyphae, not gelatinous.

Habitat: Scattered to gregarious or caespitose, in dense troops on soils supplemented with wood-chips-manure compost, in recently establish horticultural plantations and lawns.

Comments: The above description agrees with those provided by Orton (1969) and Guzmán (1983). Noordeloos (2001) regards *P. apelliculosa* as a synonym of *P. castanella*; Guzmán (1983), however, notes that these species differ in the width of the cheilocystidia [3–5(–6) µm in *P. castanella*].

Psilocybe apelliculosa is a European taxon previously unknown from America (Guzmán 1983). This report is the first for Canada and North America, where its occurrence in recently cultivated areas (i.e., the University of BC Botanical Gardens) suggests it has been imported European or Asiatic plants. *Psilocybe apelliculosa* is distinguished by its pileus without a separable pellicle and its wide cheilocystidia.

Psilocybe baeocystis (Figs. 10–11)

Specimens studied. **BRITISH COLUMBIA**, **Vancouver**, Downtown, November 28, 1981, Kroeger 89 (UBC-10235).

Basidiospores (9–)10–13(–15) × (5–)5.5–6.5(–7) µm, thick-walled, wall up to 1 µm thick; pleurocystidia absent; cheilocystidia 19–33(–40) × (5–)6–8 µm, sublageniform, frequently and irregularly branched.

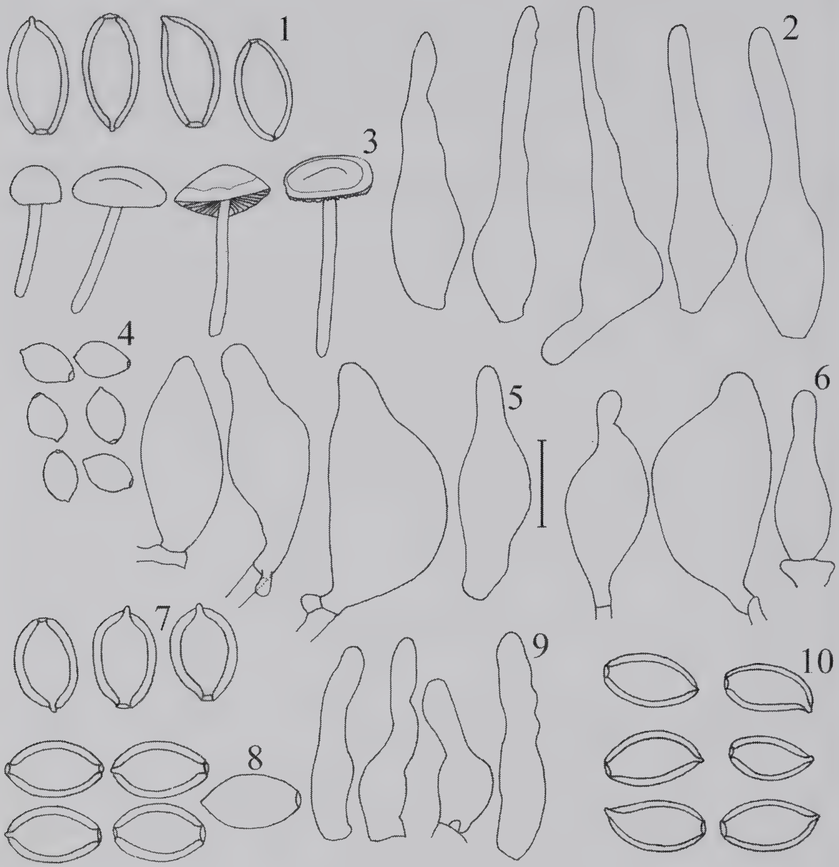


Plate I. Figs. 1–10. Canadian species of *Psilocybe*. 1–2: *P. angustispora,* 1 basidiospores, 2, cheilocystidia (both from Kroeger 590), 3–6: *P. apelliculosa*, 3 basidiomata (Kroeger 2064), 4 basidiospores, 5–6 cheilocystidia (4–5 Kroeger 868; 6 Kroeger 869), 7–9: *P. coprophila,* 7–8 basidiospores, 9 cheilocystidia (7 Kroeger 2188; 8–9 Kroeger 2198). 10: *P. baeocystis,* basidiospores (Kroeger 89). Scale bar 1–2 & 4–10: 10 µm, 3: 15 mm.

Comments: *Psilocybe baeocystis,* a common hallucinogenic fungus in British Columbia (see Table 1), was originally described from Oregon (U.S.A.) by Singer & Smith (1958) where it is also very common (Guzmán 1983). This species is distinguished by its bluing robust basidioma and strongly hygrophanous pileus, as well as its asymmetrical subellipsoid basidiospores, and growth on coniferous bark mulch in gardens and parks.

Psilocybe coprophila and *P. merdaria* (Figs. 7–9)

Specimens studied. **BRITISH COLUMBIA, Vancouver**, April 15, 1998, Kroeger 2184 (UBC-14468); May 10, 1998, Kroeger 2188 (UBC-14542); May 17, 1998, Kroeger 2198 (UBC-14500).

Annulus & veil absent; basidiospores (9–)10–13 µm long, which agree well with *P. coprophila*.

Comments: Both *P. coprophila* and *P. merdaria* are fimicolous mushrooms with subhexagonal, thick-walled basidiospores. *Psilocybe merdaria* is distinguished by its well-formed ring on the stipe and the appendiculate pileus margin and *P. coprophila* is distinguished by the lack of ring and poorly developed veil (Guzmán 1983). These fungi are very common everywhere, although *P. merdaria* is more frequent in temperate regions and *P. coprophila* is typically tropical or subtropical in distribution (Guzmán 1983). The records of *P. merdaria* and *P. coprophila* from Canada are rare and contradictory. Guzmán (1983) mistakenly based a report of *P. merdaria* and *P. coprophila* from Quebec on the same collection (Cooke 31597, MICH), which is in need of re-examination. Two other *P. merdaria* reports by Lincoff (1981) and Stamets (1996) also need verification.

Psilocybe cyanescens (Figs. 12–14)

Specimens studied. **BRITISH COLUMBIA, Vancouver**, urban zone, November 2, 1976, Guzmán 16630 (ENCB). University of British Columbia, Endowment Lands, October 11, 1981, Kroeger 156 (UBC-10241).

Basidiospores 11–12(–16) × (6–)6.5–7(–8) × (6–)6.5–7 µm, ellipsoid, thick-walled, wall up to 1.5 µm thick; pleurocystidia 17–30 × (4–)5.5–8(–9) µm, common, clavate or narrowly subglobose, both with a short cylindrical apex; cheilocystidia 18–29 × 5.5–7 µm, sublageniform or narrowly utriform, sometimes branched.

Comments: This species, like *P. baeocystis*, is another common bluing and hallucinogenic mushroom from British Columbia (see Table 1). *P. cyanescens*, originally described from England, appears to represent a complex. In fact the presence of pleurocystidia in the North American taxon suggests it may be a separate species, as in Europe *P. cyanescens* has no pleurocystidia (Watling & Gregory 1987, Guzmán 1983, Krieglsteiner 1986). The senior author is now revising this complex.

Psilocybe cyanofibrillosa (Figs. 15–20)

Specimens studied. **BRITISH COLUMBIA, Meager Mountains**, Upper Lillooet River Gorge below Plinth Peak, July 22, 1989, Kroeger 1401; August 16, 1989, Kroeger 1403, 1404, 1405; September 17, 1995, Kroeger 1790; September 18, 1995, Kroeger 1791, 1792, 1793 [all in Kroeger Herbarium and UBC, except 1404 which is also in XAL and DAOM; 1401, 1403 and 1405 also in DAOM].

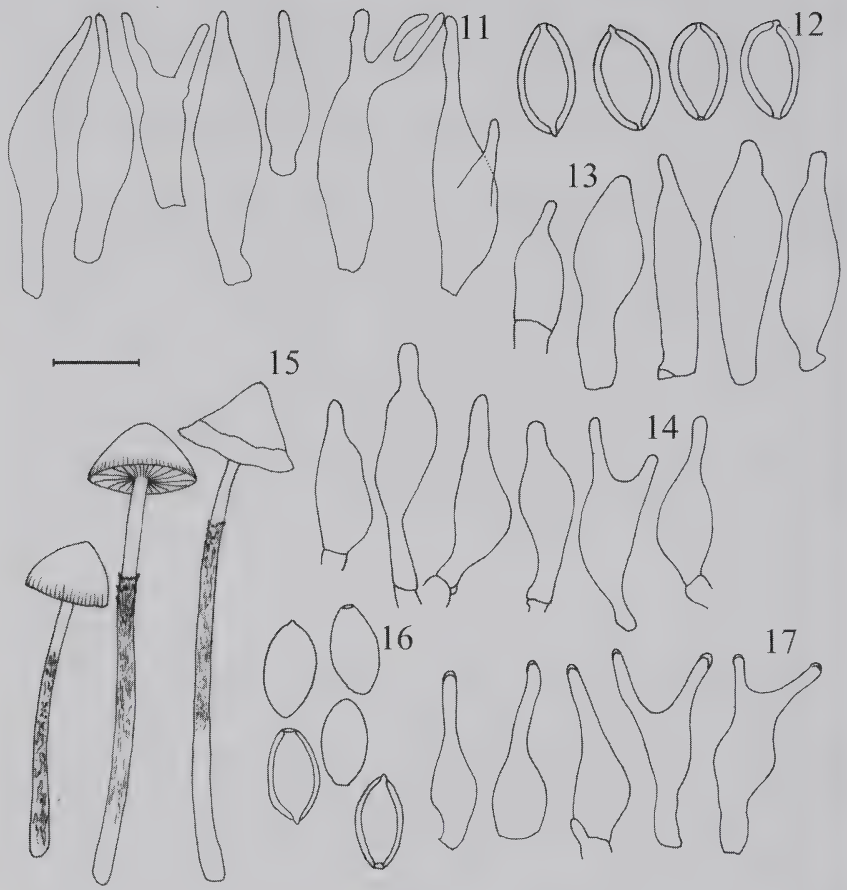


Plate II. Figs. 11–17. Canadian species of *Psilocybe*. 11: *P. baeocystis*, cheilocystidia (Kroeger 89). 12–14: *P. cyanescens*, 12 basidiospores, 13 pleurocystidia, 14 cheilocystidia (all from Kroeger 156). 15–17: *P. cyanofibrillosa*, 15 basidiomata (Kroeger 1403), 16 basidiospores, 17 cheilocystidia (both from Kroeger 1401). Scale bar 11–14 & 16–17: 10 µm, 15: 10 mm.

Pileus (5–)10–25 mm diam., conic to conic-convex or campanulate, viscid, with a well-developed gelatinous pellicle, reddish-brown to pale ochre, sometimes with a bluing margin. Lamellae sinuate, with a decurrent tooth, pale ochraceous to violaceous-ochraceous, with white edges. Stipe 20–55 × 1.5–3 mm, equal, whitish to pale ochraceous, bluing at the base, smooth above, but covered by white to grayish adpressed silky little scales from the veil to the base, hollow to stuffed with whitish mycelium. Veil white and arachnoid in young stages, the remains forming small white scales on the pileus margin and white fibrils on the upper part of the stipe, forming a scaly or floccose ring. CONTEXT pale ochraceous, bluing. BASIDIOSPORES (9–)10–12(–16) × 5–6(–6.5) × 5–6 µm, subellipsoid both in face- and side-view, thick-walled, wall up to 1 µm thick. PLEUROCYSTIDIA absent or sometimes scarce, 14.5–16 × 6–8 µm, ventricose, subglobose-mucronate or subglobose-rostrate to subfusiform or sublageniform, hyaline. CHEILOCYSTIDIA (16–)18–32 × (4–)5–7(–8) µm, sublageniform, frequently irregularly branched with two long necks, hyaline, sometimes with a dark oily drop at the apex. SUBHYMENIUM with hyaline to yellowish hyphae, 2–4 µm wide. PILEIPELLIS as an ixocutis, 70–120 µm thick, with hyaline hyphae, 1.5–4 µm wide. SUBPELLIS with inflated hyaline hyphae. CLAMP CONNECTIONS present.

HABITAT: Scattered to gregarious, in mossy sandy soil on tangled roots of *Alnus, Populus* and *Salix*, frequently inundated flat areas beside river, never in meadows.

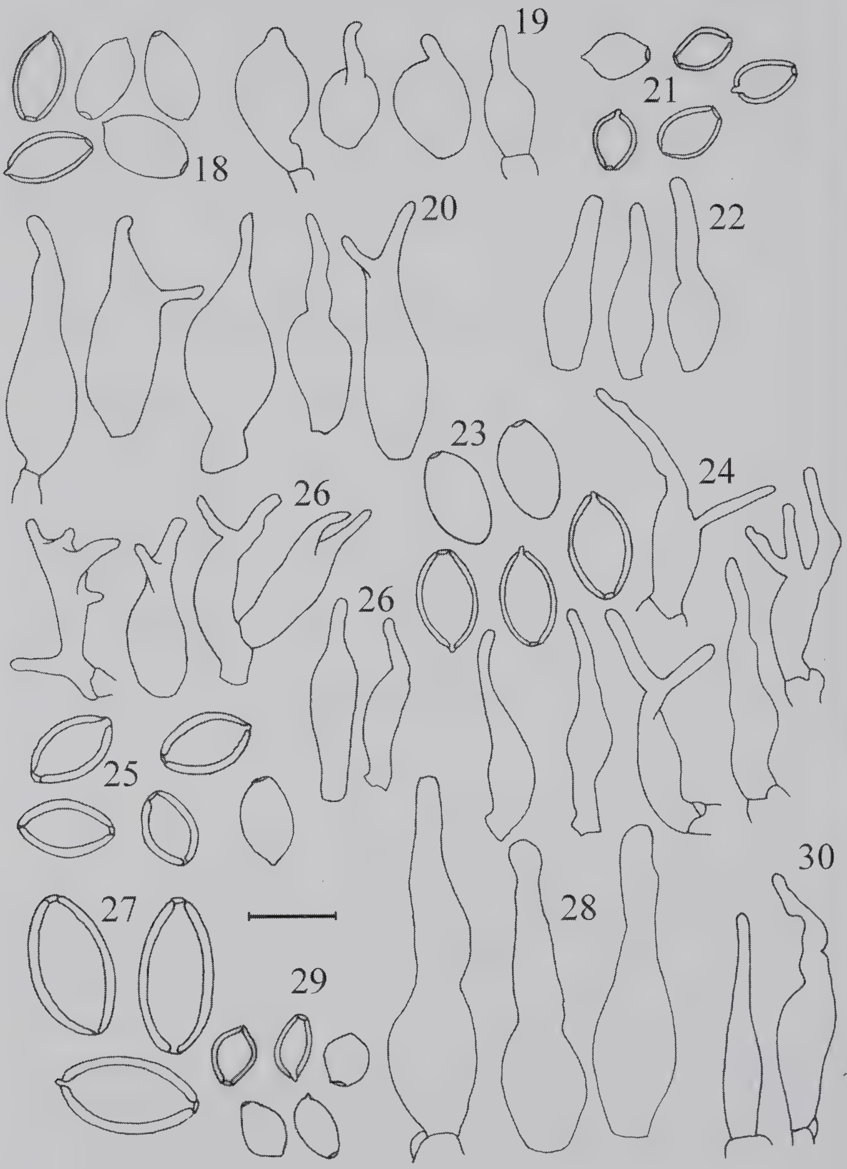
COMMENTS: Stamets et al. (1980) first described this bluing species from Washington state, U.S.A. and later (Stamets 1996) reported it from northern California to British Columbia. *Psilocybe cyanofibrillosa* appears common in British Columbia, mainly in Lillooet River region. It is close to *P. cyanescens* and is placed in section *Semilanceatae* based on its subellipsoid, thick-walled spores (Guzmán 1995). A well-developed veil that produces a scaly or floccose ring and the lack or rarity of pleurocystidia help separate *P. cyanofibrillosa* from *P. cyanescens* (Stamets 1996, Guzmán 1995). *P. cyanofibrillosa* differs from *P. semilanceata* in shorter basidiospores [(11–)12–15(–18) µm long in *P. semilanceata*] and the presence of veil (poorly developed in *P. semilanceata,* Guzmán 1983).

Psilocybe montana (FIGS. 21–22)

SPECIMEN STUDIED. **BRITISH COLUMBIA, Pasayten Valley**, October 17, 1981, Kroeger 164 (UBC-10255).

BASIDIOSPORES 7–8.5(–9) × (4–)5–5.5 × 4–5 µm, subrhomboid or subellipsoid in face-view, subellipsoid in side-view, thick-walled, wall up to 1 µm thick, dark yellowish-brown, with a broad germ pore; CHEILOCYSTIDIA 17–26 × (4–)6–7 µm; PLEUROCYSTIDIA absent. PILEIPELLIS an ixocutis up to 10 µm thick, composed of 1.5–3 µm wide, hyaline hyphae.

COMMENTS: *Psilocybe montana*, a non-bluing fungus occurring on mosses, is widespread in temperate regions (Guzmán 1983, 1995; Noordeloos 2001) but rarely reported from Canada, although Redhead (1979, 1981) cited this species indirectly. The studied BC material agrees with the classic concept of the species except for smaller cheilocystidia, cf. (15–)22–45 × 4–7.5(–10) µm (Guzmán 1983) or 17–46 × 4–8.5 µm (Noordeloos 2001). More collections should be examined in order to clarify the cheilocystidial variation.



Psilocybe pelliculosa (Figs. 23–24)

Specimens studied. **VANCOUVER, Shaughnessy**, November 15, 1980, Kroeger 51 (UBC-10231).

Basidiospores 10–13 × 6–7 µm, ellipsoid, thick-walled, wall up to 0.8 µm; pleurocystidia absent; cheilocystidia 19–37 × 4.5–6.5 µm, lageniform, frequently irregularly branched.

Comments: This bluing hallucinogenic species is common in British Columbia (see Table 1). *Psilocybe pelliculosa* resembles *P. semilanceata,* for which it is frequently mistaken — both species stain slightly blue. Smaller basidiospores and pileus that is neither conic nor papillate distinguishes *P. pelliculosa.*

Psilocybe stuntzii (Figs. 25–26)

Specimen studied. **VANCOUVER, University of British Columbia campus** in Endowment Lands, in woodchips, October 25, 1979, Kroeger 42 (UBC-10242).

Basidiospores 9.5–11 × 6–7 µm, subellipsoid or subrhomboid in face-view, subellipsoid in side-view, thick-walled, wall up to 1 µm thick; pleurocystidia absent; cheilocystidia 20–32 × 4–6.5(–8) µm, sublageniform, frequently irregularly branched.

Comments: A common bluing and hallucinogenic collybioid mushroom found in urban or suburban habitats, *P. stuntzii* is diagnosed by its annulus and subrhomboid basidiospores. The collection above agrees well with Guzmán & Ott (1977) and Guzmán (1983).

Psilocybe subcoprophila (Figs. 27–28)

Specimen studied. **BRITISH COLUMBIA, Saturna Island**, April 22, 1984, Kroeger 185 (UBC 12215).

Basidiospores 14–18 µm long, subellipsoid and thick-walled; cheilocystidia 30–45 × 6–10 µm, sublageniform; pleurocystidia absent.

Comments: As discussed above, this species is close to *P. angustispora*, from which differs in its bigger basidiospores. It is a fimicolous European species, until recently known elsewhere only from Argentina and Greenland (Guzmán 1983). Guzmán & Trappe (2005) reported it from an alpine habitat in Washington, U.S.A. The collection above was found on bovine dung in a meadow.

Plate III. Figs. 18–30. Canadian species of *Psilocybe.* 18–20: *P. cyanofibrillosa,* 18 basidiospores, 19 pleurocystidia, 20 cheilocystidia (all from Kroeger 1790). 21–22: *P. montana*, 21 basidiospores, 22 cheilocystidia (both from Kroeger 164). 23–24: *P. pelliculosa*, 23 basidiospores, 24 cheilocystidia (both from Kroeger 51). 25–26: *P. stuntzii*, 25 basidiospores, 26 cheilocystidia (both from Kroeger 42). 27–28: *P. subcoprophila*, 27 basidiospores, 28 cheilocystidia (both from Kroeger 185). 29–30. *P. subviscida* var. *subviscida*, 29 basidiospores, 30 cheilocystidia (both from Kroeger 1659). Scale bar 10 µm.

Psilocybe subviscida var. *subviscida* vs. *P. physaloides* (Figs. 29–30)

Specimen studied. **BRITISH COLUMBIA, Vancouver Island**, Lake Cowichan Research Forest, Mesachie Lake, Mesachie Hill, May 9, 1993, Kroeger 1659. (Kroeger Herbarium, UBC and XAL).

Basidioma collybioid; pileus 6–20(–25) mm diam, convex to campanulate or subplane, smooth, hygrophanous, reddish-brown to pale yellowish-brown (straw color), subviscid to dry, without a peelling pellicle, margin translucent striate when moist. Lamellae subadnexed or sinuate, reddish-brown, with concolorous edges, which are serrate or fimbriate. Stipe 20–50 × 1–2.5 mm, cylindrical, subbulbous, flexuous, hollow, reddish-brown as the pileus, blackish at the base, covered thinly with brownish-grey fibrils. Veil poorly developed. Context whitish, but brownish-red below the pileus and stipe surface. White cordons of mycelium are common at the base.

Basidiospores 6.5–7 × 4.5–5 × 4–5 µm, subrhomboid or subovoid in face-view, subellipsoid in side-view, thin-walled, wall up to 0.5 µm thick, yellowish-brown, with a broad germ pore. Pleurocystidia absent. Cheilocystidia 22.5–34.5 × 5–7 µm, sublageniform. Pileipellis subgelatinous, 10–20 µm thick, with hyaline hyphae, 1–3 µm wide.

Comments: Smith (1948) and Noordeloos (2001) both examined the holotype of *P. subviscida* cite different measurements for the basidiospores — 7–8 × 4–4.5(–5) µm by Smith, (6–)6.5–7.5(–8) × 4.5–5(–5.5) µm by Noordeloos — and cheilocystidia — 30–40 × 6–7 µm or 20–26 × 10–12 µm by Smith, 27–44 × 6–8 µm or 23–45 × 3.5–10 µm by Noordeloos.

Psilocybe subviscida is a common North American and European species (Guzmán 1983, Noordeloos 2001) that is sometimes confused with *P. physaloides*. This latter species has different interpretations by Fries, Ricken, Bresadola, Cooke, J. Lange, Orton, and Watling & Gregory (Noordeloos 2001), and Guzmán's (1983) concept of *P. physaloides* appears to represent *P. subviscida*. With Noordeloos (2001), we agree that *P. physaloides* is a nomen dubium and now refer previous New Brunswick (Canada) records of *P. physaloides* (Guzmán 1983, Stamets 1996) to *P. subviscida* (Table 1). Davidson (1930), Lowe (1969) and Redhead (1997) also have reported *P. subviscida* from British Columbia.

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Diplomitoporus allantosporus (*Basidiomycetes*): a new record for Brazil

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Abstract — *Diplomitoporus allantosporus*, collected in the Ferreira Penna Scientific Station in the state of Pará of Brazilian Amazonia, is reported as a new record to the country and the second of the species. A description of *D. allantosporus* and a key to the accepted species of the genus in Brazil are provided.

Key words — *Polyporaceae*, taxonomy, diversity

Introduction

Diplomitoporus is a cosmopolitan genus described by Domański (1970) characterised by its resupinate to effused-reflexed, light-coloured basidiomata, di-trimitic hyphal system, clamped generative hyphae, thick-walled, non-amyloid to weakly amyloid skeletal hyphae, and IKI- allantoid to ellipsoid basidiospores (Ryvarden & Gilbertson 1993). Approximately 16 species are currently recognized for the genus, 14 of which occur in the Americas (www.indexfungorum.org, www.cbs.knaw.nl, Coelho 2008a, b).

Recently four species have been recognized as new to Brazil: *Diplomitoporus dilutabilis* (Loguercio-Leite & Wright 1998), *D. taquarae* (Coelho 2008a), and *D. marianoi-rochae* (Coelho 2008b) from Southern Brazil and *D. navisporus* (Gibertoni et al. 2004) from Northern Brazil. Until now, these were also the only *Diplomitoporus* species known for the country. The present paper adds *Diplomitoporus allantosporus*, a recently described species known only from its type locality in Venezuela (Ryvarden & Iturriaga 2003). A description of *D. allantosporus* based on Brazilian material accompanied by a key to Brazilian *Diplomitoporus* species is presented below.

Material and methods

The Ferreira Penna Scientific Station (ECFPn) is a 33.000ha reserve managed by the Museu Paraense Emílio Goeldi (MPEG) and is located in the Amazonian State of Pará, 400km from Belém, Pará's capital city. This reserve is composed of typical Amazonian ecosystems with a flora that is among the richest and densest in the Amazonian basin (Lisboa 1997, 2002). The many fungi that have been collected there during the last 10 years are part of the large collection now deposited at MG (Sotão et al. 1997, 2002).

The basidioma was analysed macro- (i.e., shape, colour, hymenial surface) and micro-morphologically (i.e., hyphal system, presence/absence and measures of sterile structures and basidiospores). Microscopical observations were made from slide preparations mounted in 5% KOH and stained with 1% aqueous phloxine and/or Melzer's reagent (Ryvarden 1991). Colour designation follows Watling (1969).

Taxonomy

Diplomitoporus allantosporus Ryvarden & Iturr., Mycologia 95(6): 1067, 2003.

Basidiomata annual, resupinate. Hymenial surface saffron (49) to luteous (51); pores angular, 2–3/mm. Context thin.

Hyphal system dimitic, generative hyphae hyaline, 3–5 μm diam., clamped, thin to slightly thick-walled; skeletal hyphae hyaline to yellow, 4–5 μm in diam., thick walled. Basidia clavate, 10–12 × 3–5 μm. Basidiospores allantoid, smooth, 5–6.25 × 1.5–2.5 μm, thin-walled, occasionally guttulate, hyaline, IKI-.

Material examined: BRAZIL. State of Pará: Municipality of Melgaço, Floresta Nacional de Caxiuanã, ECFPn (51'27"17° W, 1'44"12° S), 23.IX.1996, *H. Sotão et al. 96-41* (MG).

Remarks: *Diplomitoporus allantosporus* is diagnosed by the size and shape of its basidiospores. It resembles *D. venezuelicus* Ryvarden & Iturr., which is differentiated by smaller (4–4.5 × 1.2–1.5 μm), cylindric basidiospores and smaller, round pores, 6–8/mm (Ryvarden & Iturriaga 2003). The Brazilian species *D. dilutabilis* has angular to elongated pores, trimitic hyphal system and cylindrical to slightly allantoid basidiospores (Loguercio-Leite & Wright 1998), while *D. navisporus* has also round, regular pores, but trimitic hyphal system and navicular basidiospores (Gibertoni et al. 2004). *Diplomitoporus taquarae* is distinguished by smaller pores [(2–) 4–5 (–6)/mm] and narrower generative hyphae [(1.8–) 2–2.8 (–3.2) μm diam.] (Coelho 2008a), while *D. marianoi-rochae* has larger pores [(0.5–) 1–2/mm], branched contextual skeletal hyphae, broader spores (3.5–9.5 × 1.5–3 μm), and abundant hyphidia or dendrohyphidia when fresh (Coelho 2008b). This represents the second occurrence of *D. allantosporus,* previously known only from its type locality in Venezuela, and the first report for Brazil.

Working key to Brazilian species of *Diplomitosporus*

1a. Hyphal system trimitic 2

1b. Hyphal system dimitic 3

2a. Basidioma resupinate to effused-reflexed, pores 4–6/mm, angular to radially elongated, basidiospores cylindrical to slightly allantoid, 4.5–5.5 × 2.5–3 µm .... *D. dilutabilis*

2b. Basidioma resupinate, pores 6–7/mm, round, basidiospores cylindrical to navicular, 4.5–5.4 × 2–2.7 µm .... *D. navisporus*

3a. Pores up to 2/mm, hyphidia or dendrohyphidia present ...... *D. marianoi-rochae*

3b. Pores smaller, more than 2/mm, hyphidia or dendrohyphidia absent 4

4a. Basidioma resupinate, pores 2–3/mm, generative hyphae 3–5 µm diam. with large clamps, basidiospores 5–6 × 1.2–1.5 µm .... *D. allantosporus*

4b. Basidioma resupinate, soon reflexed at the margins, pores 4–5/mm, generative hyphae 2–2.8 diam., basidiospores 4.4–6.4 × 1.2–1.8 µm .... *D. taquarae*

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Paradoxa gigantospora comb. nov. from China

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Abstract – A new combination, *Paradoxa gigantospora,* is proposed for the truffle *Tuber gigantosporum* that was first described in 1991 based on a specimen collected from southwestern China. *Paradoxa gigantospora* is distinct in that it invariably has only one spore per ascus, a defining character for the genus *Paradoxa.* This represents the second species for the genus *Paradoxa* and the first time this genus has been recorded in China.

Keywords – *Pezizales,* taxonomy, fungus

Introduction

In 1991, a new truffle species, *Tuber gigantosporum* was described by Wang & Li (1991) based on a specimen collected in 1988 from Huidong County, Sichuan, China. The species was distinguished by ascospores larger than those produced by all other species of *Tuber*. The species also had the distinction of having only invariably one ascospore per ascus. A second collection of *Tuber gigantosporum* was obtained from Yongren County, Yunnan, China in 2002.

In 1935 Mattirolo established the genus *Paradoxa* based on *Paradoxa monospora* Mattir., which is characterized by its invariably 1-spored asci as illustrated by Montecchi & Sarasini (2000). We now believe that *Tuber gigantosporum* is congeneric with *Paradoxa* Mattir. and here transfer the species from *Tuber* to *Paradoxa.*

Materials and methods

The type specimen of *Tuber gigantosporum* was collected from Huidong County, Sichuan, China in 1988 and the second specimen from Yongren County, Yunnan, China in 2002. They are deposited in the Herbarium of Institute of

Applied Ecology, Chinese Academy of Sciences (IFS, not yet listed in the Index Herbariorum). Macroscopic characters were described from fresh specimens. Photographs were made and microscopic features described after examining fresh material or freeze microtome sections in cotton blue under a Nikon E400 microscope.

Taxonomy

Paradoxa gigantospora (Y. Wang & Z. P. Li) Y. Wang **comb. nov.** FIGURES **1–6**

MYCOBANK MB 512137

BASIONYM: *Tuber gigantosporum* Y. Wang & Z. P. Li, Acta Mycol. Sinica 10(4): 263. 1991.

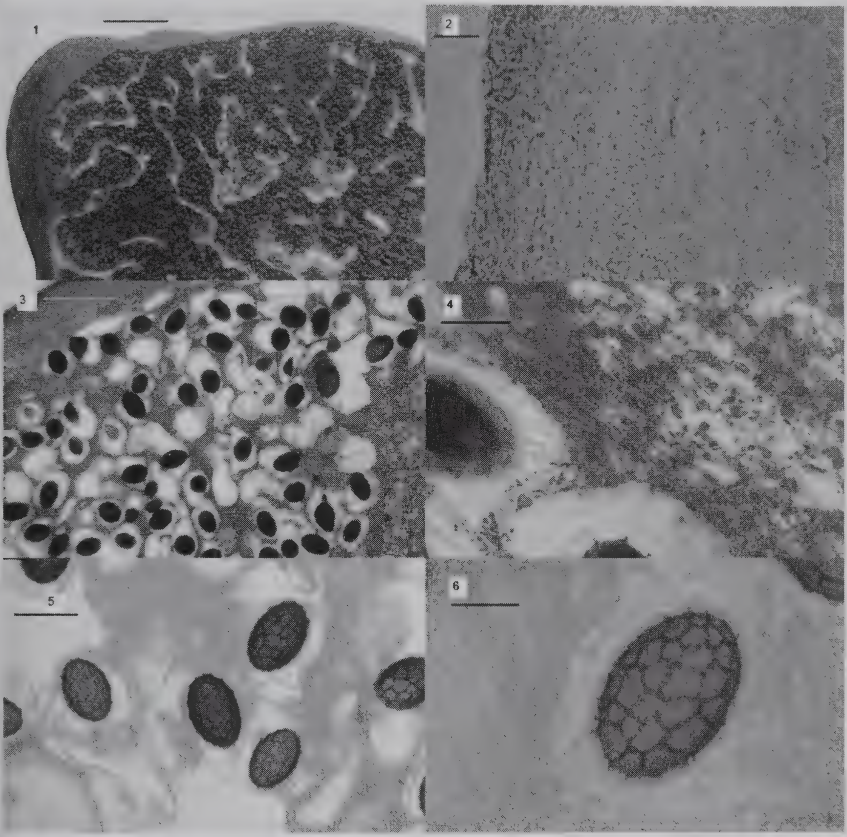
ETYMOLOGY: the specific epithet refers to the giant ascospores of this species.

ASCOMATA (Fig. 1) solid, irregularly subglobose and slightly lobed, pale yellow-brown to brown, up to 15 mm broad, rough with yellow-brownish, scurfy patches and lines. ODOR not distinctive. PERIDIUM (Fig. 2) 190–230 μm thick, of interwoven hyphae 3–4 μm broad at the septa, many cells inflated up to 10 μm, the out-layer 70–90 μm thick and brownish, the inner-layer hyaline and grading into the gleba tissue. GLEBA (Fig. 3, 4) whitish in youth, becoming brown to dark reddish brown at maturity, marbled with distinct, whitish, branched veins merging with the peridium at many points and some penetrating the peridium to the ascomatal surface; fertile tissue of hyaline, interwoven hyphae, 3–4 μm broad at the septa, many cells inflated up to 20 μm. ASCI invariably 1-spored, mostly subglobose, stemless, prior to spore formation hyaline, thin-walled, subglobose, when containing a spore hyaline, ellipsoid, 160 × 140 μm, the wall up to 4 μm thick, randomly enclosed in the fertile tissue. ASCOSPORES (Fig. 5 and 6) pale brown in youth, becoming dark reddish brown at maturity, ellipsoid, (80–)105–115(–120) × (55–)70–75(–80) μm excluding ornamentation of a reticulum up to 2 μm tall, the meshes irregularly polygonal, varying in size, 7–8 along the spore and 3–5 across.

ECOLOGY AND DISTRIBUTION – Hypogeous under *Pinus yunnanensis* and *Quercus* spp., August to December. Known from Huidong County, Sichuan and Yongren County, Yunnan, China.

SPECIMENS EXAMINED – **CHINA. Sichuan province:** Huidong County, August 1988, Y. Wang 89921 (*IFS 89921* - holotype). **Yunnan:** Yongren County, 17 December, 2002, H. T. Hu (*IFS 0201*).

COMMENTS – Mattirolo (1935) proposed the genus *Paradoxa* for *P. monospora*, which is distinguished by having only one spore per ascus (Montecchi & Sarasini 2000). It is, therefore, appropriate to transfer *Tuber gigantosporum* from *Tuber* to *Paradoxa*. The two *Paradoxa* species are closely related by their similar ascomata, gleba and spore color in addition to the one-spored asci. However, *P. gigantospora* differs from *P. monospora* in having very large, ellipsoid



Figs. 1-6. Fig. 1. *Paradoxa gigantospora.* Section of ascorcarp showing the gleba, *Hu 0201* (bar = 2.0 mm). **Fig. 2.** Section of peridium, *Wang 89921* (bar = 60 µm). **Fig. 3.** Section of gleba showing the ascal tissues, composed of 1 spored-asci with no stalks, *Wang 89921* (bar = 250 µm). **Fig. 4.** Section of gleba showing the interascal tissues, composed of colourless, interwoven hyphae 3 - 4 µm in diameter, *Wang 89921* (bar = 60 µm). **Fig. 5.** Asci and ascospores, *Wang 89921* (bar = 90 µm). **Fig. 6.** Ascospore, *Wang 89921* (bar = 40 µm).

ascospores (105–115 × 70–75 µm) compared with those of *P. monospora* that measure 50 × 60 (– 70) µm. This is only the second species of the genus *Paradoxa* and the first time this genus has been recognized in China.

These two closely related species are widely separated: *P. monospora* is known only from Italy and *P. gigantospora* only from southwestern China. This implies a close biogeographical relationship between the Mediterranean and southwestern China. This hypothesis is also supported by the results of studies of Chinese truffle flora in the southwestern China over the past 20 years that show interesting parallels between the two regions. For example, *Tuber uncinatum* (=*Tuber aestivum*) and *Tuber excavatum* were found in both regions (Song et al. 2004, Wang at al. 2008). Likewise, Chinese black truffles, the *Tuber indicum* complex in southwestern China, resemble the European Périgord black truffle (*Tuber melanosporum*) (Yamanaka et al. 2001, Jeandroz at al. 2008). Finally, *Tuber pseudoexcavatum* from southwestern China is closely related to the European species *Tuber brumale* (Jeandroz at al. 2008).

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A new species of *Phaeoramularia* on *Cimicifuga* (*Ranunculaceae*)

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Abstract —A new species, *Phaeoramularia cimicifugae* on *Cimicifuga dahurica (Ranunculaceae)* is reported. Latin diagnosis, illustration and English description of the new species are provided. Distinctions between the new species and its closely related species — *P. clematidis, P. lomaensis, P. sudanensis* and *P. delphinii* — are discussed. The type and isotype specimens are deposited in HMAS and HMJAU.

Key words —imperfect fungi, taxonomy

Introduction

A fungus occurring on *Cimicifuga* specimens was collected from Inner Mongolia in China. Its multiseptate, cylindrical, catenate conidia produced on fasciculate conidiophores that emerged through stomata indicated that it belonged in the genus *Phaeoramularia*. After comparing our specimen with all other *Phaeoramularia* species previously reported on *Ranunculaceae*, we found it different enough to propose as a new *Phaeoramularia* species, described below.

Taxonomy

Phaeoramularia cimicifugae F.Y. Zhai, Y.L. Guo & Yu Li, **sp. nov.** FIG.1
MycoBank MB 512082

Maculae amphigenae, punctatae, orbiculares vel irregulares, 3.0–10.0 mm diam., aliquando confluentes, atro-brunneae, centro luteo-brunneae, extus halonatis luteis vel luteo-brunneis. Caespituli amphigeni. Mycelium immersum. Stromata nulla vel parva.

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Tab.1. Comparisons among five related *Phaeoramularia* species

Features	Species	*P. cimicifugae*	*P. clematidis*	*P. lomaensis*	*P. sudanensis*	*P. delphinii*
Leaf spots		Present	Present	Absent	Absent	Present
Fruiting		Amphigenous	Hypogenous	Hypogenous	Hypogenous	Amphigenous
Stromata (µm)		None or small	17–28 diam	50 diam ,35 tall	none	18–79 diam.
Conidiophores	fascicle	Loosely/densely	5–8	~ 12	~ 12	~ 80
	branch	Present	Absent	Present	Present	Absent
	color	Olivaceous brown	Pale olivaceous brown to pale brown	Mod. olivaceous	Mod. olivaceous	Olivaceous to mod. olivaceous brown
	length (µm)	25–91	20–48.5	≤ 200	≤ 175	26–69
	width (µm)	3.9–7.8	2–4	4–6	4–5	2.5–5
Conidial scars (µm)		2–3	1	1.5	1.5–2	1–2.5
Conidia	color	Pale olivaceous brown to olivaceous brown	Subhyaline to very pale brown	Mod. olivaceous	Pale olivaceous	Olivaceous to mod. olivaceous brown
	septa	1–5 (most 1–3)	1–2	0–5 (most 1–3)	1–5	0–3 (most 0–1)
	length (µm)	23–57	14–38	17–74	16–78	12–37
	width (µm)	2.6–5.2	2.5–5	4–6.5	4–6.5	3.5–8

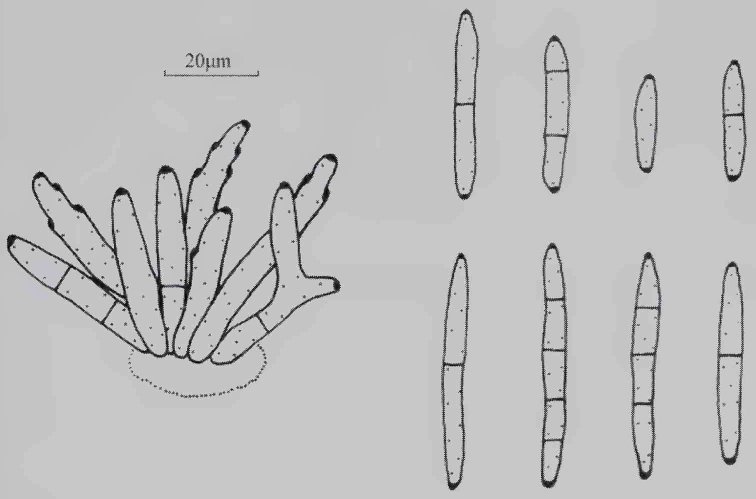

Fig.1 *Phaeoramularia cimicifugae*
Conidiophores and conidia (HMAS 143916)

Conidiophora emergena per stomata, laxe vel dense fasciculata, olivaceo-brunnea, laevia, ramosa, recta vel curvata, 0–7-geniculata, ad apicem truncata vel conico-truncata, 0–3-septata, 25.0–91.0 × 3.9–7.8 μm. Cicatrices conspicue incrassatae, 2.0–3.0 μm latae. Conidia cylindrica, pallide olivaceo-brunnea vel olivacea brunnea, catenata, laevia, recta vel leviter curvata, ad apicem conico-truncata, ad basin obconico-truncata, 1–5-septata, imprimis 1–3-septata, 23.0–57.0 × 2.6–5.2 μm.

Hab. in foliis vivis Cimicifugae dahuricae *(Turcz.) Maxim. (*Ranunculaceae*), Motianling, Xingan, Inner Mongolia, 9 VIII 1991, leg. Y.L. Guo, no. 1646 (HMAS 143916,* ***Holotypus:*** *HMJAU 30004, Isotypus), no. 1658 (HMAS 143917).*

Leaf spots amphigenous, punctiform, circular or irregular, 3.0–10.0 mm diam., sometimes confluent, blackish brown, with a yellowish brown center and yellow to yellowish brown halo on the upper surface, paler on the lower surface. Fruiting amphigenous. Mycelium immersed. Stromata none or small. Conidiophores emerging through stomata, loosely or densely fasciculate, olivaceous brown, paler towards the apex, smooth, branched, straight to curved, 0–7-geniculate, regular or irregular in width, sometimes narrower towards the apex, truncate or conically truncate at the apex, 0–3-septate, 25.0–91.0 × 3.9–7.8 μm. Conidial scars conspicuously thickened, 2.0–3.0 μm wide. Conidia cylindrical, pale olivaceous brown to olivaceous brown, catenulate, smooth, straight or slightly curved, conically truncate at the apex, obconically truncate at the base, 1–5-septate, chiefly 1–3-septate, 23.0–57.0 × 2.6–5.2 μm.

Comments: Crous & Braun (2003) reduced *Phaeoramularia* to synonymy with *Passalora,* which mainly differs from *Phaeoramularia* by forming solitary conidia. Crous & Braun (2003) maintain that amongst cercosporoid hyphomycetes the formation of single or catenate conidia was not tenable as a distinguishing generic character, citing support from ITS and 5.8S rDNA sequence analysis (Crous et al. 2001). However, we wish to emphasize morphological characteristics and believe that the mode of conidia formation, singly or in chains, is a major character delimiting cercosporoid hyphomycetes, including *Phaeoramularia* and *Passalora*. We therefore prefer to recognize *Phaeoramularia* as a separate genus.

Four other *Phaeoramularia* species also occur on *Ranunculaceae*: *P. clematidis* S.K. Singh & R.K. Chaudhary (Singh et al. 1995), *P. lomaensis* Deighton (Deighton 1979), *P. sudanensis* Deighton (Deighton 1979) and *P. delphinii* F.Y. Zhai et al. (Zhai et al. 2007). Among the four species, however, *P. clematidis, P. lomaensis* and *P. sudanensis* are associated with *Clematis*, while *P. delphinii* is associated with *Delphinium*; none of them is associated with *Cimicifuga*.

Phaeoramularia clematidis (found on *Clematis gouriana* Roxb.) exhibits hypogenous fruiting, well-developed stromata, bears 5–8 conidiophores in a fascicle that are unbranched, darker, shorter and narrower and bear smaller conidial scars than found in *P. cimicifugae*, and produces conidia that are mostly solitary, occasionally catenate, or (more rarely) branched, subcylindrical, paler, 1–2-septate, and shorter.

P. lomaensis and *P. sudanensis* (also on *Clematis* spp.) do not form leaf spots, exhibit hypogenous fruiting, bear ~12 conidiophores per fascicle that are paler, usually branched, rarely simple, sinuous or geniculate, longer, narrower and bear smaller conidial scars, and produce conidia that are paler, longer, and slightly wider. In addition *P. lomaensis* forms well-developed stromata and subcylindric conidia, and *P. sudanensis* produces slightly curved or sometimes slightly sigmoid conidia.

P. delphinii (found on *Delphinium* sp.) possesses well-developed stromata, produces conidiophores that are fairly densely fasciculate, unbranched, paler, shorter and narrower and bear smaller conidial scars, and produces conidia that are catenulate and often in branched chains, ellipsoid to cylindric, fewer septate, paler, shorter and wider.

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Hyaloscyphaceae (*Ascomycota*) growing on tree ferns in Mexico

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Abstract — Five species of *Lachnum* growing on fern leaves in cloud forest are reported from Mexico. *Lachnum fimbriiferum*, *L. oncospermatis* and *L. singerianum* are new records for the country, *L. pteridophyllum* and *L. varians* are new records for Veracruz State.

Key words — ascomycete, discomycete, diversity

Introduction

Hyaloscyphaceae is one of the major families in the *Leotiomycetes*, with more than 500 species (Kirk et al. 2001) and a worldwide distribution. In Mexico this family has not yet been monographed and few references about this group of fungi are available (Chacón & Guzmán 1983, Chacón & Medel 1993, Galán et al. 1994, Medel & Calonge 2004). The authors found several ascomycetes growing on tree fern leaves while studying the diversity of *Ascomycota* in cloud forest in the Veracruz State. A literature search showed that only two species, *Lachnum varians* (as *D. varians* var. *varians*) from Chiapas and *Lachnum pteridophyllum* (as *D. varians* var. *pteridophyllum*) from Oaxaca, have been reported from Mexico growing on this type of host (Cantrell 2004, Haines 1980, Nagao 1996, Nagao & Doi 1996, Samuels & Rogerson 1990, Raitviir 2004, Spooner 1987, Wu et al. 1998, Zhuang & Wang 1998). The only checklist of fungi from the cloud forest (Chacón & Medel 1993) cites 594 species of fungi; of the 96 ascomycetes listed, only one species, *Lachnum brasiliense* (Mont.) J.H. Haines & Dumont from Veracruz, belongs to the *Hyaloscyphaceae*. Tree ferns in Mexican cloud forest are one of the most conspicuous and abundant elements, easily seen because of their shape and size. The aim of this study is to report the species of *Hyaloscyphaceae* associated with tree ferns, especially those found in the cloud forests of Veracruz, Mexico.

Materials and methods

Specimens were collected in 1986–89 and 2004–06 during two surveys of of cloud forest remnants in the central region of Veracruz. Tissues were examined microscopically in 5% KOH to record measurements or in Melzer´s reagent (MLZ) to study the amyloid reaction; tissues from one species were mounted in Lugol solution (IKI) to determine hemiamyloidity. Spore averages (denoted by *x*) were determined from 25 spores per species; Q-values are cited according to Largent et al. 1977. All studied specimens are kept in the Mycological Collection of the Instituto de Ecología herbarium (XAL). Plant hosts were named to species when samples were suitable for reliable identifications.

Studied species

Lachnum fimbriiferum (Berk. & M.A. Curtis) J.H. Haines,
Nova Hedwigia 54: 103 (1992) Figs 1–2, 11–12
≡ *Peziza fimbriifera* Berk. & M.A. Curtis in Berkeley, J. Linn. Soc., Bot. 10: 367 (1868)
≡ *Dasyscyphus fimbriifer* (Berk. & M.A. Curtis) Sacc., Syll. Fung. 8: 452 (1889)

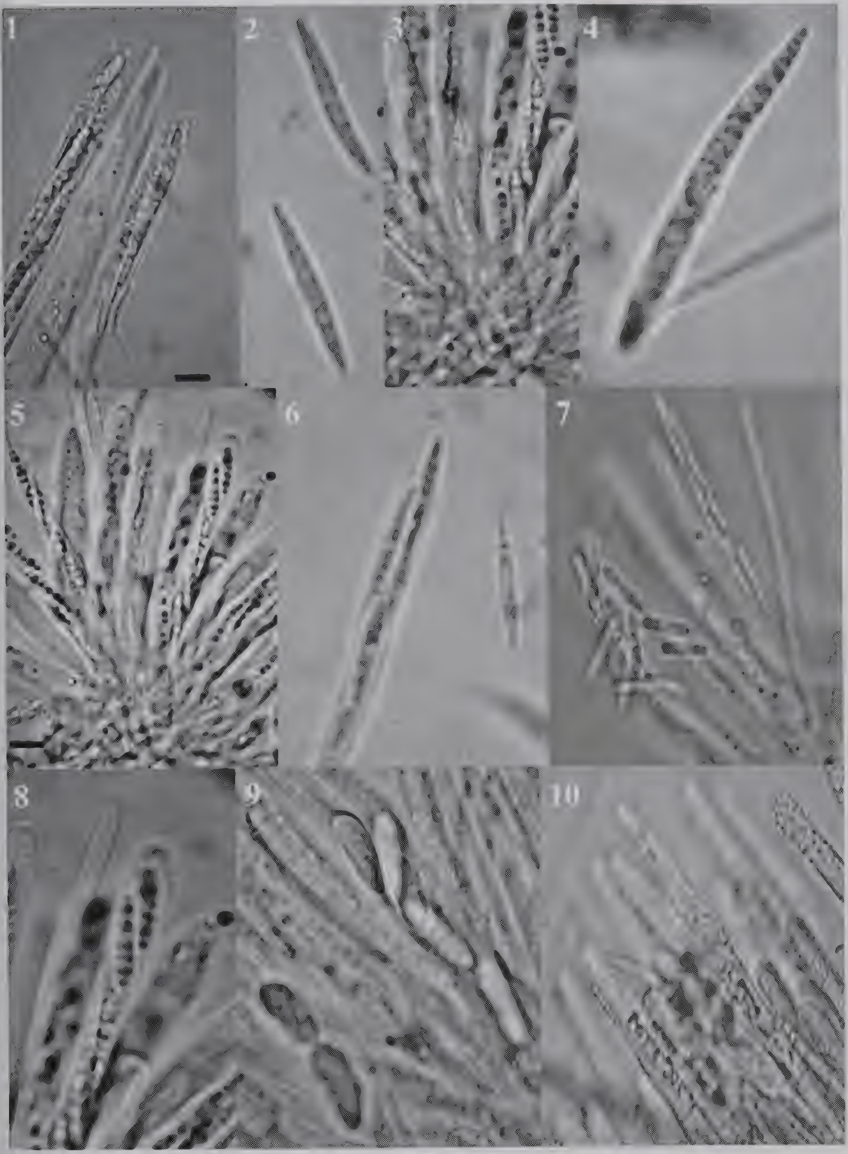
Apothecia globose to cup shaped, 0.3–0.5 mm diam, disc pale yellow or cream color when dry, covered with superficial hairs white to yellowish, stipitate. Asci 70–80 × 8–9 µm, in KOH, cylindrical, MLZ+, with a small blue *Hymenoscyphus*-type plug, 8-spored, without croziers. Spores fusiform with rounded ends, (15–) 20–30 × 3 (4) µm, x = 11.2 × 1.2 µm (Q>3.0), slightly curved, with small globules in MLZ, KOH. Paraphyses filiform, longer than asci up to 2 µm, 1–3 µm diam, hyaline, simple to branched and septate near the base. Hairs cylindrical, 100–300 × 4–5 µm, septate, hyaline, finely granulate.

Habitat: gregarious, on decaying leaves of *Alsophila firma* (Baker) D.S. Conant, *Cyathea bicrenata* Liebm., other *Cyatheaceae* spp. and *Dicksonia sellowiana* Hook., in cloud forest at 1400–1680 m altitude.

Known distribution: Colombia, Cuba, Dominican Republic, Ecuador, Jamaica, Venezuela and Mexico (reported here).

Studied material: MEXICO. VERACRUZ. Municipality of San Andrés Tlalnehuayocan, Rancho Agüita Fría, road to San Andrés Tlalnehuayocán, 18/5/2004, Medel 869; 23/7/2005, Medel 973, 976, 982, 985, 988, 990; Municipality of Rafael Lucio, Santa Bárbara Farm, km 10 NE highway Xalapa-La Joya, 3/10/1986, Medel 200, 209; 2/6/1987, Medel 360, 361, 366; 14/5/1987, Medel 343, Chacón 1672.

Notes— This species is not easy to recognize using macroscopic characters since many species of *Lachnum* growing on tree ferns are similar, but the cream color of the disc and the white hairs are diagnostic. Spore, ascus, and paraphysis sizes differentiate this species from *L. singerianum*, a related species that Haines (1980) considered a variety of *L. fimbriiferum*. In comparing spore sizes, however, we found enough differences in the studied material to recognize



Figs. 1-10. 1-2: *Lachnum fimbriiferum*. 1: asci, paraphyses and ascospores; 2: ascospores close up (Medel 869). 3-4: *L. oncospermatis*. 3: asci and paraphyses; 4: ascospores close up (Medel 333); 5-6: *L. pteridophyllum*. 5: asci: paraphyses and ascospores; 6: asci and ascopores close up (Medel 870); 7: *L. singerianum*. Asci, ascospores and paraphyses (Medel 923); 8-10 *L. varians*. 8: asci and ascospores; 9: ascospores close up; 10: hairs showing amorphous resin masses (Tapia 851).

Scale bar: 10 μm; figure 5: 15μm. Photographs R. Medel.

two independent species: spore lengths never exceed 10 µm in *L. singerianum*, in contrast to the 15–30 µm range in *L. fimbriiferum*. Although this was the most common species found on ferns in our study, this is the first record for Mexico.

Lachnum oncospermatis (Berk. & Broome) M.L. Wu & J.H. Haines,
in Wu, et al., Mycotaxon 67: 346 (1998) FIGS 3–4, 13
≡ *Peziza oncospermatis* Berk. & Broome, J. Linn. Soc. Bot. 14: 105 (1873)
≡ *Dasyscyphus oncospermatis* (Berk. & Broome) Sacc., Syll. Fung. 8: 452 (1889)

Apothecia infundibuliform, 0.3–0.5 mm diam, disc dark yellow or stramineus when dry, covered with buff yellow or whitish hairs, stipitate, some apothecia have bifurcate stipes. Asci cylindric-clavate, 80–90 × 10–11 µm in KOH, with a small pore, *Hymenoscyphus*-type, MLZ+, without croziers. Ascospores long fusiform with one end wider than the other, 30–40(–45) × 2–3 µm, x = 35.3 × 2.5 µm (Q>3.0) with clearly small globules in KOH. Paraphyses filiform, 1–2 µm. Hairs cylindrical, 3–4 µm, septate, yellowish, roughened by granules.

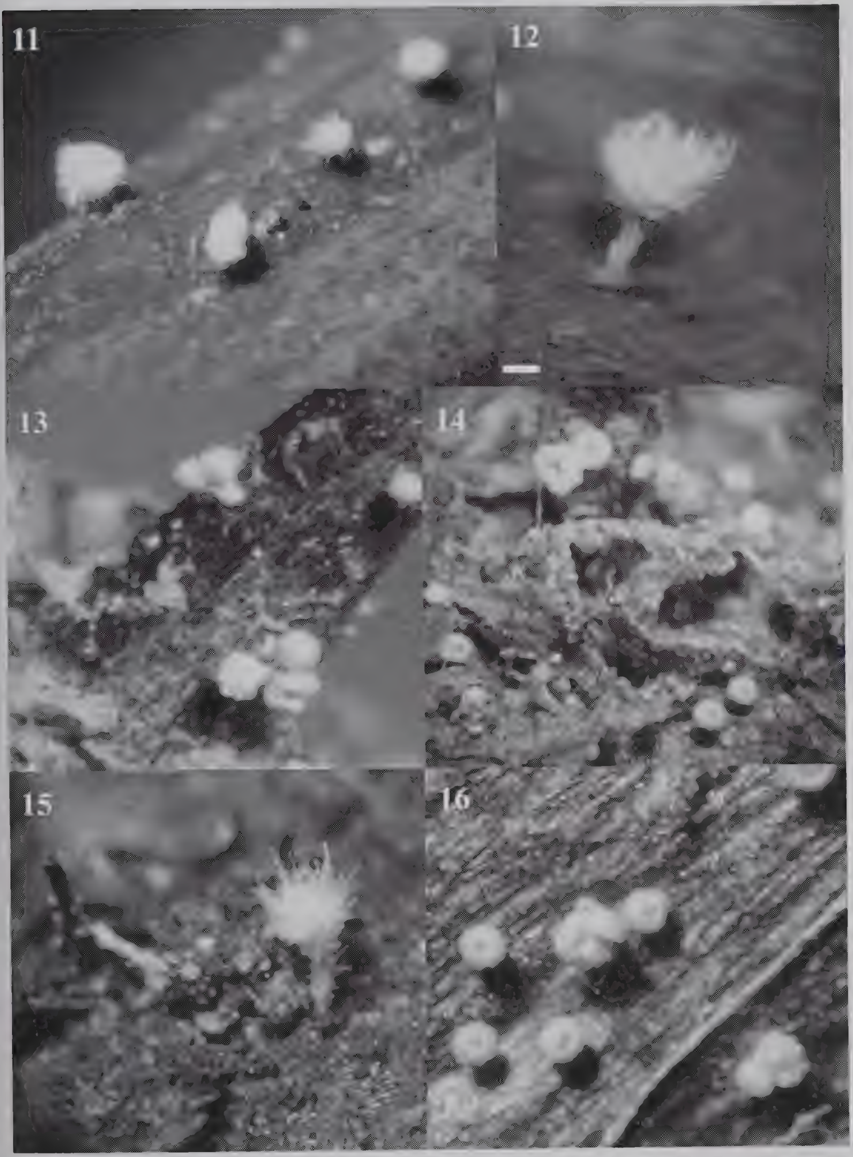
HABITAT: gregarious on decaying leaves of *Dicksonia sellowiana*, in cloud forest at 1680 m altitude.

KNOWN DISTRIBUTION: Australia, Indonesia, Taiwan, The Philippines, Sri Lanka, and Mexico.

STUDIED MATERIAL: MEXICO. VERACRUZ. Municipality of Rafael Lucio, Santa Bárbara Farm, km 10 NE highway Xalapa-La Joya, 14/10/1987, Medel 333.

NOTES— The solitary or bifurcate stipe in some apothecia and the long spores are diagnostic for this species. Haines (1980) cites spores up to 32 µm for the typical variety of *L. oncospermatis* and refers specimens with longer (36–67 × 2.5–3.5 µm) spores to *L. oncospermatis* var. *macrospora*. Wu et al. (1998) reported spores of (24–)27–39(–42) × 2–3 µm. Spores from Medel 333 are up to 45 µm and agree with the spore size recognized by Wu et al. (1998) for this species. *Lachnum varians,* which produces similarly colored ascomata, produces spores shorter than in *L. oncospermatis*. Haines (1980) mentioned that this species grows on *Cyatheaceae* and *Liliaceae,* and the record on *Oncosperma* from Ceylon is not confirmed. Wu et al. (1998) reported this species growing on two genera of *Cyatheaceae* from China. The material from Mexico was growing on *Dicksonia*, a taxon not previously known as a host for this species. This is the first record for Mexico.

Lachnum pteridophyllum (Rodway) Spooner,
Biblioth. Mycol. 116: 470 (1987) FIGS 5–6, 14
≡ *Dasyscyphus pteridophyllus* Rodway, Pap. Proc. R. Soc. Tasmania 1920: 158 (1921)
≡ *Dasyscyphus varians* var. *pteridophyllus* (Rodway) J.H. Haines, Mycotaxon 11: 209 (1980)
≡ *Lachnum varians* var. *pteridophyllum* (Rodway) M.P. Sharma, Nova Hedwigia 43: 411 (1986)



Figs. 11-16. 11-12: *Lachnum fimbriiferum*. 11 apothecia; 12 apothecium close up (Medel 869); 13: *L. oncospermatis*. Apothecia showing bifurcate stipes (Medel 333); 14: *L. pteridophyllum*. Apothecia (Medel 870); 15: *L. singerianum*. Apothecium (Medel 923); 16: *L. varians*. Apothecium (Tapia 851). Scale bar: 0.5 mm. Photographs R. Medel.

Apothecia globose to funnel shaped, 0.3–0.5 mm diam, disc light to dark yellow when dry, covered with pale yellow hairs, stipitate. Asci cylindric-clavate, 40–55(–60) × 5–6(–7) µm, with a blue pore *Hymenoscyphus*-type MLZ+, 8-spored, without croziers. Ascospores narrowly fusiform, 11–15(–17) × 1–2 µm, x = 12.3 × 1.7 µm (Q>3.0), with small globules in KOH, less evident in MLZ. Paraphyses narrow, lanceolate, up to 2 µm diam. Hairs 100–200 × 4–5 µm, hyaline to yellow in mass.

Habitat: gregarious on decaying leaves of *Dicksonia sellowiana, Cyathea divergens* var. *tuerckheimii* (Maxon) R.M. Tryon and other *Cyathea* spp. At 1400–1680 m altitude.

Known distribution: Colombia, Dominican Republic, Jamaica, Mexico, Panamá, Peru, Puerto Rico, New Guinea, New Zealand, Taiwan, Tasmania and Venezuela.

Studied material: MEXICO. VERACRUZ. Municipality of San Andrés Tlalnehuayocan, Rancho Agüita Fría, road to San Andres Tlalnehuayocan, May 8, 2004, Medel 860, 867, 870; 23/5/2004, Medel 880, 882; July 23, 2005, Medel 978; Municipaliy of Rafael Lucio, Santa Barbara Farm, km 10 NE highway Xalapa-La Joya, October 14, 1987, Medel 368.

Notes— *Lachnum pteridophyllum* is distinguished by spores with acute ends that are not longer than 20 µm (Spooner 1987). It is morphologically very similar to *L. varians*, which produces shorter (≤ 15 µm) spores with rounded ends. Haines (1980) treated *L. pteridophyllum* as a variety of *L. varians,* but Spooner (1987) later argued that spore size and shape differences justified elevation of the taxon to species level. Haines (1980) first reported *L. pteridophyllum* from Oaxaca State. This is the first record for Veracruz State.

Lachnum singerianum (Dennis) W.Y. Zhuang & Zheng Wang,
Mycotaxon 67: 27 (1998) Figs 7, 15
≡ *Dasyscyphus singerianus* Dennis, Kew Bull. 13: 465 (1959 ['1958'])
≡ *Dasyscyphus fimbriifer* var. *singerianus* (Dennis) J. H. Haines, Mycotaxon 11: 199 (1980)

Apothecia discoid to globose, 0.3–0.5 diam., disc whitish yellow or pale orange when dry, covered with whitish to yellow hairs, shortly stipitate. Asci cylindric-clavate 45–55 × 5–6 µm, with a blue pore *Hymenoscyphus*-type, MLZ+, without croziers. Ascospores ellipsoid, (7–)8–10 × 1(–2) µm, x = 9.2 × 1.7 µm (Q>3.0), with evident globules in KOH, non-septate, hyaline. Paraphyses cylindric up to 2 µm diam, hairs cylindrical, 150–200 × 4–5 µm, septate, finely granulate.

Habitat: gregarious, on decaying leaves of *Alsophila firma* and *Dicksonia sellowiana* at 1400–1680 m altitude.

Known distribution: in the Andean region of Bolivia to Venezuela, China, Jamaica, and Mexico.

Studied material: MEXICO. VERACRUZ. Municipality of Xalapa, Botanical Garden Francisco J. Clavijero, km 2.5 old highway Xalapa-Coatepec, August 3, 1989, Medel 445 (XAL); municipality of San Andrés Tlalnehuayocan, road to San Andres Tlanehuayocán, Rancho Aguita Fría, June 6, 2005, Medel 923; October 12, 2005, Medel 1122.

Notes— Haines (1980) first cited *L. singerianum* as a variety of *Dasyscyphus fimbriifer*, but Zhuang and Wang (1998) regard it as an independent species. They cite a wider (≤ 3 µm) spore size than found in the Veracruz specimens (Zhuang & Wang 1998), which otherwise have the general morphology and host (*Cyatheaceae,* cf. Haines 1980). *Lachnum singerianum* resembles *L. fimbriiferum,* which differs in its longer ascospores, asci, and paraphyses. This is the first report of *L. singerianum* from Mexico.

Lachnum varians (Rehm) M.P. Sharma, Nova Hedwigia 43: 411 (1986) Figs 8–10, 16
≡ *Dasyscypha varians* Rehm, Hedwigia 39: 94 (1900)

Apothecia globose to funnel shaped 0.3–0.5 mm diam, disc pale orange when dry, stipitate, densely covered with whitish or pale buff hairs with amorphous masses of resin, which do not dissolve in KOH or Melzer´s reagent. Ascospores long elliptical with rounded ends, 10–15 × 3–4(–5) µm, $x = 12.9 \times 4.1$ µm (Q>3.0). Asci cylindric-clavate, 70–80 × 10 µm, MLZ–, hemiamyloid in Lugol's solution, without croziers. Paraphyses filiform up to 2 µm diam. Hairs cylindric, up to 100 × 3–5 µm, septate, thin-walled.

Habitat: gregarious on decaying leaves of *Alsophila firma* in cloud forest at 1300–1680 m altitude.

Known distribution: Australia, Hawaii, New Guinea, New Zealand, South America, The Caribbean, and Mexico.

Studied material: MEXICO. VERACRUZ. Municipality of Xalapa, around the Conecalli, km 2.5 old higway Xalapa-Coatepec, August 27, 1991, Tapia 851; municipality of San Andres Tlanehuayocan, road to San Andrés Tlalnehuayocan, Rancho Agüita Fría, May 23, 2004, Medel 882.

Notes—*Lachnum varians* is characterized by short (≤ 15 µm) spores with rounded ends and MLZ– asci. Although spores of studied material were wider than those referred by Haines (1980) and Spooner (1987) for the species, other characters fit the concept of *L. varians* including the host (*Cyatheaceae* family). It is close to *L. pteridophyllum,* which differs in its longer spores with acute ends. Haines (1980) previously reported *L. varians* for Mexico from Chiapas State, but this is a first record from Veracruz State.

Discussion

Tree ferns are common to Mexican cloud forests, and there is a great diversity of fungi associated with these plants. The five *Lachnum* species described above were the most common ascomycetes growing on Mexican tree ferns, but there are other small unidentified discomycetes (e.g. species of *Orbilia* Fr. and *Cyathicula* De Not.) represented in the cloud forests as well. Sixty percent of eight taxa cited by Haines (1980) known to occur on tropical ferns are represented in Mexico. The fragmentary distribution and extensive human use of the Mexican cloud forests make them vulnerable and likely to disappear. There is a decline on the diversity of tree ferns in Mexico and the associated fungi are endangered.

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Rust fungi on *Saccharum* species from Pakistan

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Abstract — Four species of rust fungi are described on three species of *Saccharum*. Among these, *Puccinia melanocephala* and *P. miscanthi* are new records for Pakistan. *Puccinia coronata* var. *avenae* and *P. kuehnii* are already known from this area. *Saccharum* is a new host for the *Puccinia coronata* species complex from Pakistan.

Key words — *Andropogoneae*, *Poaceae*, sugarcane

Introduction

The plant genus *Saccharum* is placed in the tribe *Andropogoneae* of family *Poaceae*. It is a genus of 35–40 species, occurring throughout the tropics and extending to warm temperate regions. Nine species of *Saccharum* occur in Pakistan and one of them, *Saccharum officinarum* L. (sugarcane), is cultivated as an important commercial crop (Cope 1982). Sugarcane, the source of sugar, is being grown on 0.96 million hectares with a production of 42 million tonnes in Pakistan. Unfortunately, its full production is hindered due to biotic and abiotic stresses. Diseases such as red rot, Pokka boeng, smut, rusts, mosaic and red stripe are some of the major biotic stresses that may reduce the yield by 10–77% (Ali 2006). Common species of rust fungi that attack *Saccharum* worldwide include orange rust, *Puccinia kuehnii*, *P. melanocephala* (= *P. erianthi*), and *P. miscanthi*.

During a survey of rust fungi of Pakistan, it was found that *Saccharum* is a favorable host for rust fungi. Four species of rust fungi are herein described on three species of *Saccharum* from different localities. Among these, *Puccinia melanocephala* and *P. miscanthi* are new records for Pakistan. *Puccinia kuehnii* and *P. coronata* var. *avenae* have already been reported from Pakistan, but *Saccharum* is a new host for the *Puccinia coronata* species complex from Pakistan.

Materials and methods

Specimens were collected from different areas of Pakistan. Dried herbarium specimens identified as *Puccinia kuehnii* were borrowed from the Herbarium, Department of

Botany, University of the Punjab, Lahore (LAH). Freehand sections of infected tissue and spores were mounted in lactophenol and gently heated to boiling. The preparations were observed under a NIKON YS 100 microscope and photographed with a digipro-Labomed. Drawings of spores and paraphyses were made using a Camera Lucida (Ernst Leitz Wetzlar, Germany). Spore dimensions were measured using an ocular micrometer. At least 25 spores were measured for each spore stage. The rust fungi were identified by comparing their characters with the descriptions and illustration made by Cummins (1971) and Hiratsuka et al. (1992). The rusted specimens have been deposited in LAH.

Description of taxa

1. ***Puccinia coronata* var. *avenae*** W.P. Fraser & Ledingham, Sci. Agric. 13: 315 (1933). (Figs. A–B)

=*Puccinia coronifera* Kleb., Z. Pflanzenkrankh. Pflanzenschutz 4: 135 (1894).

Spermogonia and aecia unknown in Pakistan. Uredinia on adaxial leaf surface, mostly amphigenous, cinnamon brown, 0.09–0.2 × 0.2–0.3 mm. Urediniospores ovoid to obovoid or ellipsoid, 16–21 × 20–31 µm; wall 1.5–2 µm thick, golden brown to cinnamon brown, echinulate; germ pores (5–) 9–11, scattered, with slight or no cuticular caps; pedicel hyaline, short, 4–8 × 10–12 µm. Paraphyses clavate to cylindrical, hyaline, 12–19 µm thick at apex, 55–60 µm long. Telia abaxial, covered by epidermis, with a few brown stromatic paraphyses, 0.06–0.1 × 0.1–0.2 mm, black. Teliospores clavate to ellipsoid or oblong, not or slightly constricted at septa, 11–16 × 45–60 (–65) µm excluding digitations, digitations 2–several, 6–15 µm long; wall 1–1.5 µm thick, smooth, chestnut brown, paler basally; germ pore 1 per cell; pedicel short, not collapsing, brown, 7–9 × 12 µm long.

Material examined: On *Saccharum ravennae* (L.) L., Pakistan, North West Frontier Province (NWFP), Sheran, 13th August, 2007, NSA # 40 (LAH Herbarium No. NSA 1013).

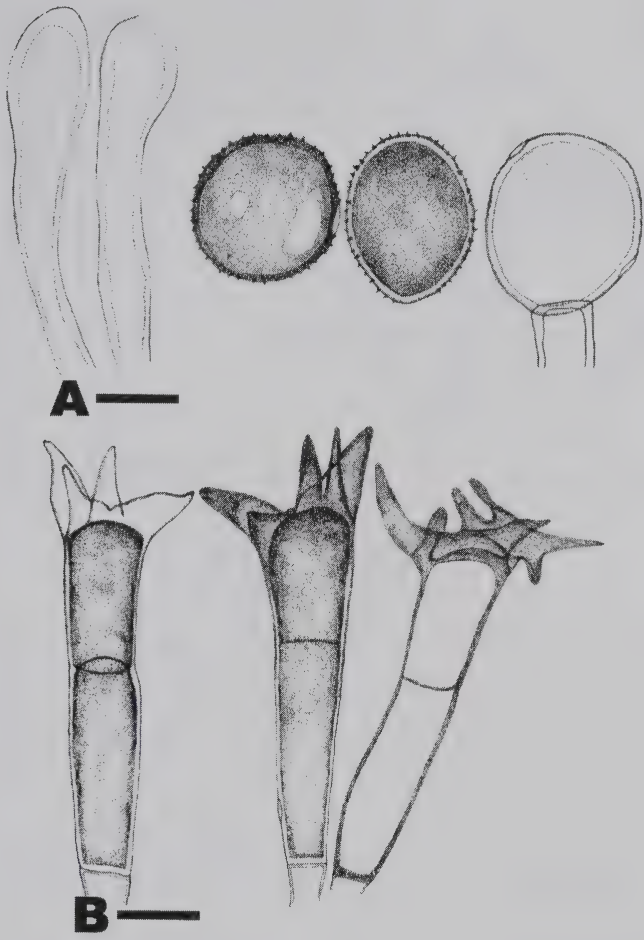
Puccinia coronata var. *avenae* was previously reported on *Avena* and other grasses (Cummins 1971, Hiratsuka et al. 1992), and on *Elymus repens* (L.) Gould (Afshan et al. 2008). According to Cummins (1971), variety *avenae* has been proved capable of infecting various grasses, occasionally on grasses where oats are common. *Saccharum* is a new host for the *Puccinia coronata* species complex from Pakistan.

2. ***Puccinia kuehnii*** E.J. Butler, Ann. Mycol. 12: 82 (1914). (Figs. C–D)

= *Uromyces kuehnii* W. Krüger, Ber. Versuchs Stat. f. Zuckerrohr West-Java, Kagok-Tegal 1: 120, 1890. (based on uredinia)

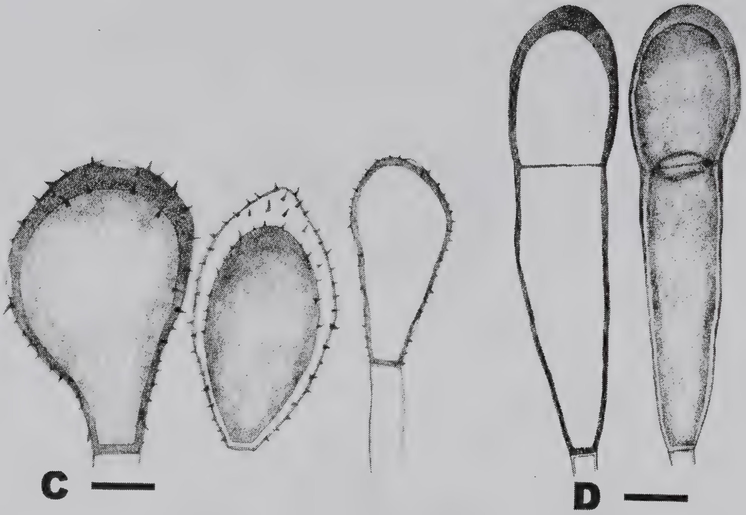
= *Uredo kuehnii* (W. Krüger) Wakker & Went, De Ziekten van het Suikerriet Java, Leiden, p. 144. 1898.

Spermogonia and aecia not found. Uredinia mainly on abaxial leaf surface, sometimes amphigenous, cinnamon brown to golden brown, 0.09–0.2 × 0.2–0.3



Figs. A–B: *Puccinia coronata* var. *avenae* on *Saccharum ravennae*
(A). Echinulated urediniospores and clavate paraphyses
(B) Lucida drawing of coronate teliospores.
Scale bars = 10 µm.

mm. Urediniospores ovoid to obovoid or pyriform, sometimes broadly ellipsoid, 23–30 × 33–48 µm; wall up to 3 µm thick at sides, sometimes uniformly thick, but usually with apex up to 9 µm thick, golden brown to yellowish brown with orange granules, moderately echinulate with evenly distributed spines; germ pores 4–5, equatorial, or tending to equatorial; pedicel hyaline, 6–8 × 24 µm. Paraphyses inconspicuous, not always observed; if present, basal or peripheral, pyriform to clavate, extremely thin walled, delicate, hyaline to pale brown. Telia hypophyllous, erumpent, 0.2–0.4 × 0.1–0.5 mm, with few paraphyses.



Figs. C–D: *Puccinia kuehnii*
(C). Urediniospores (D). Teliospores.
Scale bars = 10 μm.

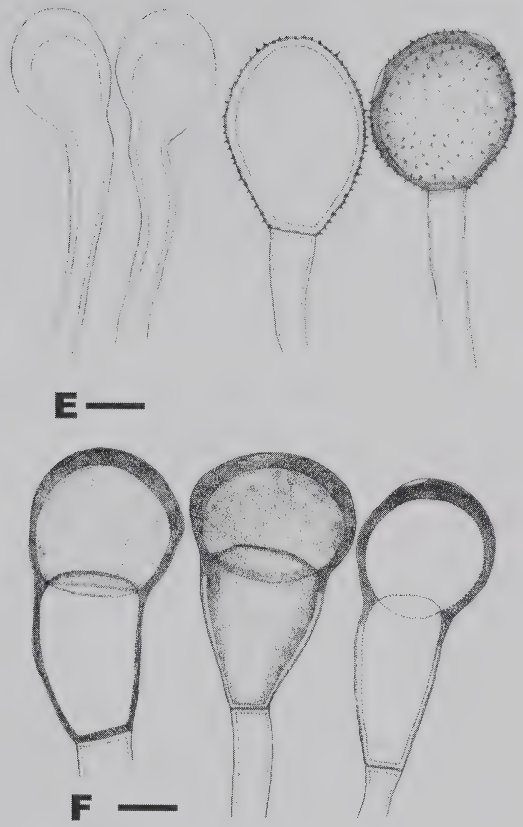
Teliospores oblong or clavate to fusiform, not or slightly constricted at septa, 18–26 × (26–) 30–40 (–45) μm; wall 0.5–1 μm thick, smooth, chestnut brown, paler basally; germ pores obscure; pedicel short, hyaline, 7–8 × 12 μm long.

Material examined: On *Saccharum spontaneum* L., *S. munja* Roxb., *S. bengalense* Retz., Pakistan, Punjab, Lahore, Minchin Abad, Faisal abad. 23rd December, 2007. # 43 (LAH).

Specimen examined: On *Erianthus ravennae* (L.) P. Beauv. (≡ *Saccharum ravennae*), Lahore, 08th January, 1950, S. Ahmad; *Saccharum munja*, Lahore, 19th November, 1950, S. Ahmad, # 3077; *Saccharum ravennae*, Lahore, 27th April, 1969, S. Ahmad, # 21855 (LAH).

Puccinia kuehnii was first described as *Uromyces kuehnii* because of the presence of apically thick-walled urediniospores that were apparently mistaken as teliospores. It was later renamed as *Uredo kuehnii*, since the telial stage was not found and the apically thick-walled spores were proven to be urediniospores (Virtudazo et al. 2001). Butler (1914) found teliospores of this fungus on *Saccharum spontaneum* and named the species as *Puccinia kuehnii*. Virtudazo et al. (2001) made a taxonomic revision of *Puccinia* species viz. *P. melanocephala* and *P. kuehnii*, causing rust diseases on sugarcane to clarify their morphological characteristics.

From Pakistan, *P. kuehnii* is previously reported on *S. bengalense*, *S. officinarum* and *S. spontaneum* from Lahore and Faisalabad (Ahmad et al. 1997).



Figs. E–F: *Puccinia melanocephala* on *Saccharum spontaneum*
(E) Echinulated urediniospores and capitate paraphyses (F) Teliospores.
Scale bars = 10 μm.

3. ***Puccinia melanocephala*** Syd. & P. Syd., in Sydow et al., Ann. Mycol. 5: 500 (1907). (Figs. E–F)
= *Puccinia erianthi* Padwick & A. Khan, Mycol. Pap. 10: 10 (1944).

Spermogonia and aecia not found in Pakistan. Uredinia mainly on abaxial leaf surface, sometimes amphigenous, cinnamon brown to dark brown, subepidermal, erumpent, 0.09–0.2 × 0.2–0.3 mm. Urediniospores obovoid to ellipsoid, 21–27 × 28–35 (–38) μm; wall 2–2.5 μm thick, golden brown to cinnamon brown, densely echinulate; germ pores 4–5, equatorial; pedicel hyaline, short, 4–5 × 15–20 μm. Paraphyses abundant, capitate, golden brown to cinnamon brown, 50–100 μm long, with head 15–24 μm in diam., 6–9 μm thick at lower side, with the wall 1.0–3.0 μm thick in the stipe and 5–15 μm in the head. Telia abaxial, covered by epidermis, but early exposed, 0.06–0.1 ×

0.1–0.2 mm, black, with long capitate paraphyses. Teliospores mostly clavate or ellipsoid to broadly ellipsoid, 16–22 × (28–) 32–45 µm, slightly constricted at septa; wall 1–1.5 µm thick, smooth, apex chestnut brown to dark brown, but paler basally; apex 2–5 µm thick, rounded; germ pore 1 per cell, in upper cell apical or sub–apical, in lower cell near the septum; pedicel short, not collapsing, brown, 8–10 µm wide and up to 12 µm long. Three-celled spores occasional.

Material examined: On *Saccharum spontaneum*, Pakistan, North West Frontier Province (NWFP), Bara Gali, at 2393m a. s. l., 06th November, 2007, # 41 (LAH).

Puccinia melanocephala has previously been recorded on *Saccharum officinarum*, *Erianthus rufipilus Griseb.* and *E. ravennae* (Cummins 1971).

P. melanocephala is reported for the first time from Pakistan

4: ***Puccinia miscanthi*** Miura, Flora of Manchuria and East Mongolia 3: 302 (1928). (Figs. G–H)

= *Puccinia eulaliae* Barclay, J. Asiatic Soc. Bengal 60: 216 (1891).
= *Puccinia miscanthicola* F.L. Tai & C.C. Cheo, Bull. Chinese Bot. Soc. 3: 67 (1937).

Spermogonia and aecia unknown in Pakistan. Uredinia epiphyllous, cinnamon brown, 0.09–0.2 × 0.2–0.3 mm. Urediniospores subglobose to obovoid or ellipsoid, 22–28 × 25–33 µm; wall 2–3 µm thick, light brown to cinnamon brown, echinulate; germ pores 2–5, equatorial; pedicel hyaline, short, 6–8 × 8–10 µm. Paraphyses capitate, hyaline or becoming brown with age, 19–24 µm thick at the apex and 6–8 µm thick at lower side, 78–120 µm long. Telia hypophyllous, covered by epidermis, 0.06–0.1 × 0.1–0.2 mm, black, loculate with a few brown paraphyses surrounding sori. Teliospores oblong to clavate, 11–19 (–24) × (38–) 40–70 (–75) µm, not or slightly constricted at septa; wall 1–1.5 µm thick, smooth, brown to cinnamon brown; apex 4–8 µm thick, truncate or rounded, mostly chestnut brown; germ pore 1 per cell, upper sub–apical, lower at the equator or near septum; pedicel short, light brown, not collapsing, thick walled, 6–7 × 4–13 µm. Few one–celled spores also observed.

Material examined: On *Saccharum ravennae*, Pakistan, Northern Areas, Hunza, at 2,440 m a. s. l., 13th August, 2007, # 14. (LAH)

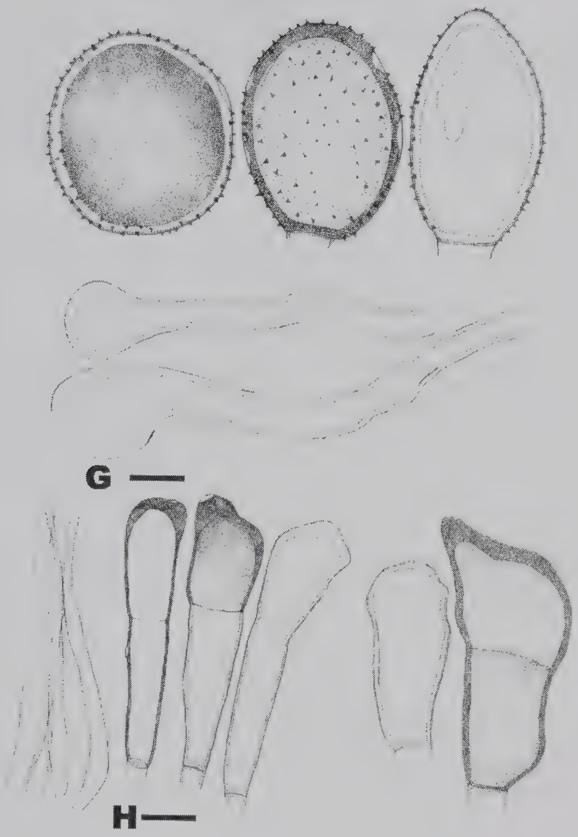
Cummins (1971) reported *Puccinia miscanthi* on *Saccharum narenga* Wall. This is the first report of this species from Pakistan.

Key to the *Puccinia* species on *Saccharum* in Pakistan:

1 Teliospores with thick, coronate apex having 2 to several digitations, urediniospores with 5–9 scattered germ pores . . . . *P. coronata* var. *avenae*

1* Teliospores with apex rounded to truncate, urediniospores with up to 5, equatorial germ pores 2

2 Telia loculate with a few brown paraphyses surrounding the sori. Teliospores mostly 40–70 um long, with thick, truncate to rounded apex . . . . *Puccinia miscanthi*



Figs. G–H: *Puccinia miscanthi* on *Saccharum ravennae.*
(G) Urediniospores showing equatorial germ pores and capitate paraphyses.
(H) 1–2 celled teliospores with paraphyses.
Scale bars = 10 µm.

2* Telia not loculate, with capitate paraphyses, apex thick, rounded to conical. Teliospores mostly less than 40 um long. 3

3 Teliospores 32–48 um long, with abundant, long, capitate paraphyses, apex thick, rounded. Uredinia with distinctly capitate paraphyses, urediniospores with dense echinulation having regularly spaced spines and uniformly thickened walls . . . . *Puccinia melanocephala*

3* Teliospores with few capitate paraphyses, apex thick, rounded to conical. Teliospores 30–40 um long. Uredinia with indistinctly capitate paraphyses, urediniospores with moderate echinulation having evenly distributed spines and apically or uniformly thickened walls . . . . *Puccinia kuehnii*

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Neotypification of *Marasmius amazonicus*

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Abstract — The holotype of *Marasmius amazonicus* was lost during the Second World War due to the destruction of the Berlin-Dahlem herbarium, and, given the nonexistence of isotypes, we propose a neotypification for the species.

Key words — *Marasmiaceae*, diversity, neotropics, taxonomy

Introduction

The genus *Marasmius* was established by Fries' Floram Scanicam, published in 1835–37, and currently contains around 2,000 widely distributed species. *Marasmius amazonicus* is one of the most beautiful members of the genus and belongs to series *Leonini* subsection *Siccini* section *Sicci* (Singer 1976). It was originally collected near Juruá Miry, Amazonas State, Brazil, by Ule in 1901 and sent to Germany, where Hennings (1904) described it as a new taxon, naming it after its native region. During the Second World War, the type specimen was lost after the destruction of the Berlin-Dahlem herbarium, where the original material was stored. Singer (1976) in his monograph of the tribe *Marasmieae* for Flora Neotropica gave a detailed description of the species after material collected in Bolivia, where he commented on the loss of the type, although without designing a neotype.

This taxon was rediscovered in Atlantic Forest areas in Rio Grande do Norte State, more precisely in Parque Estadual Dunas de Natal (Dunes State Park of Natal), a conservation area noted for its rich species diversity and interesting discoveries (Baseia & Calonge 2005, Fazolino et al. 2008). Therefore, the purpose of this paper is to establish a Brazilian neotype, providing a detailed description with comments and illustrations of the species.

Material and methods

The studied specimens were collected in the "Parque Estadual Dunas de Natal", a coastal Atlantic Forest reserve located in Natal city, Rio Grande do Norte State, Brazil. The park covers an area of 1,172 ha. Average annual temperature is around 26°C, and rainfall, between 800 mm and 1 555 mm per year, falling predominantly between March and August. The fresh specimens were color-coded according to Kornerup & Wanscher (1978) and described following the usual techniques used in taxonomic studies of *Marasmius* (Gilliam 1976, Singer 1976, 1986; Desjardin & Petersen 1989, Desjardin et al. 2000, Wright & Albertó 2002, Wannathes et al. 2004).

Taxonomy

Marasmius amazonicus Henn., Hedwigia 43: 183. 1904.

Pileus 16–58 mm diam., hemispheric to more often campanulate, central disc smooth, slightly umbonate; margin decurved, sulcate; glabrous, but with a velutinous surface aspect, dry, membranous, hygrophanous, edge regular, purple or deep lilac or dark "Magenta" (KW 13E8 13F8), with darker purple central disc (KW 14F8) and presenting numerous buff dots which are oval or irregularly rounded spots varying in diameter (2–3 mm), brownish yellow (KW 4A4) in center and pale yellow (KW 4A3) at the margin. Lamellae free, sub-distant (18–22) with no lamellulae, wide (2 mm broad), equal, neither intervenose nor branched, pale yellow (KW 4A3), margin with regular edges and color similar to pilear surface (KW 12F8), the surface inter lamellae similar in color to the pileus. Stipe 50–70 × 1–2 mm, glabrous, smooth, shining, woody when dry but resistant cartilaginous in young basidiomata, hollow, equal, central, terete but sometimes compressed, blackish brown to chestnut color at the base and pale cream at the apex, similar to lamellae color, though (KW 6F6–5E7), with a well developed basal mycelium cream coloured (KW 3A2). Context thin, dextrinoid. Basidiospores 13.75–16.25(–17.5) × 2.5–3.75 μm (Qm = 4.3, n = 20 basidiospores), fusoid, smooth, hyaline, thin-walled, inamyloid (Fig. 2c). Basidia not noticed. Pleurocystidia absent. Cheilocystidia similar to the broom cells of the pilear surface, main body cylindric-clavate, hyaline, thin to slightly thick-walled, 10–15 × 5–6.25 μm; apical setulae 5–7.25 μm broad (Fig. 2b). Hymenophoral trama regular, dextrinoid, with hyaline hyphae, thin-walled, septate, with small clamp connections but not noticed at all septa, 5–7.5 μm diam. Pileipellis hymeniform, composed by broom cells of the *Siccus*-type, cylindrical to clavate, main body, hyaline when individualized and slightly chestnut color when in group, thick-walled, 10–16.25 × 3.75–7.5 μm, apical setulae 3.75-5 μm broad (Fig. 2a). Habitat: growing on decaying leaves.

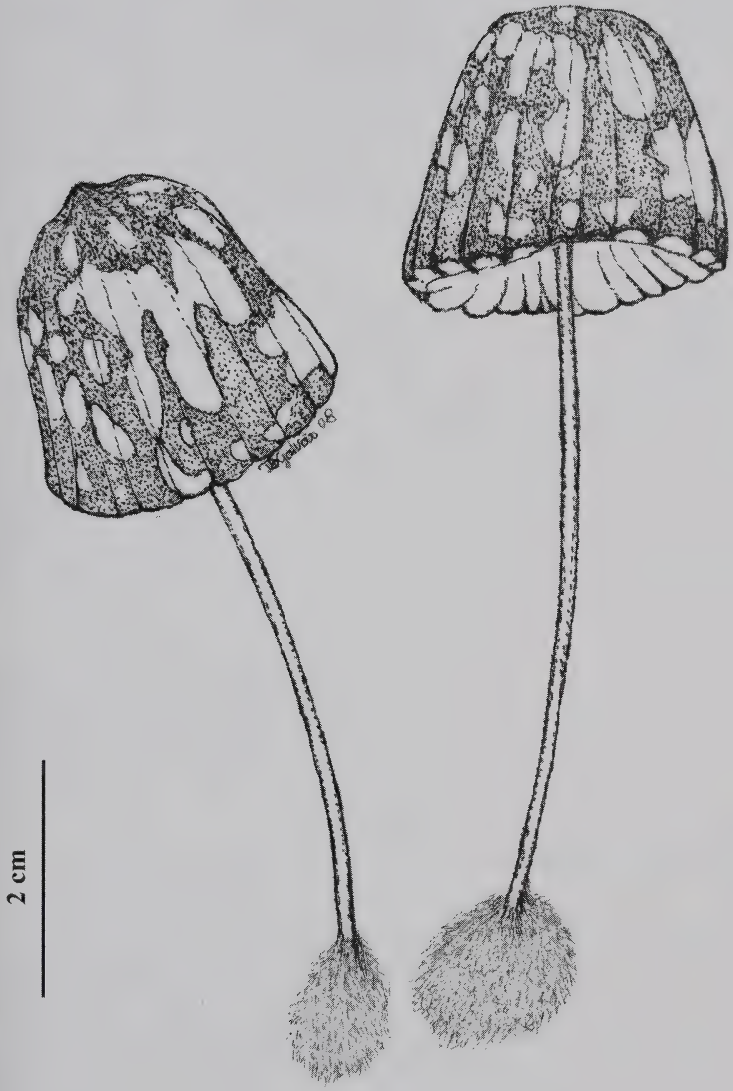

Fig. 1. *Marasmius amazonicus*, basidiomata (from neotype).

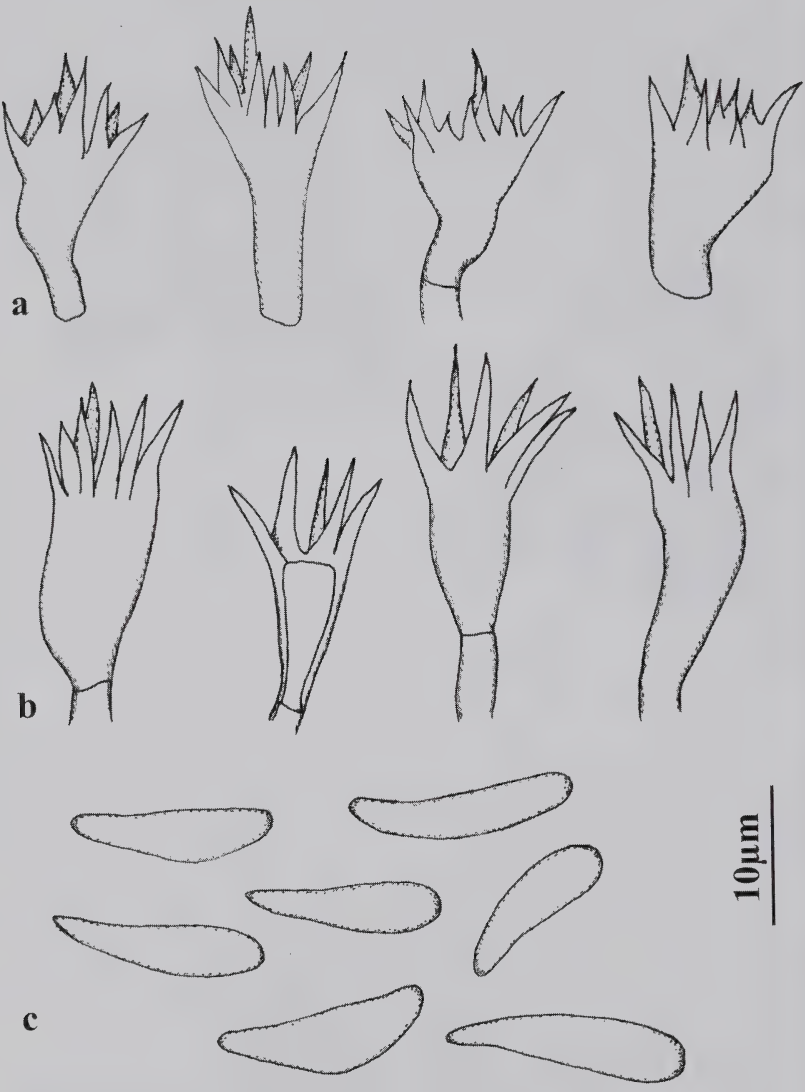

Fig. 2. *Marasmius amazonicus* (from neotype).
a. broom cells. **b.** Cheilocystidia. **c.** Basidiospores.

Material examined: BRAZIL, RN, **Natal**: Parque Estadual Dunas de Natal, 27.V.2006, *J.J.S. Oliveira, I.G. Baseia, B.D.B. Silva* (Neotypus hic designatus UFRN-251); 11.VI.2007, *J.J.S. Oliveira, I.G. Baseia s.n.* (UFRN); 14.VI.2007, *J.J.S. Oliveira, I.G. Baseia s.n.* (UFRN).

REMARKS—*Marasmius amazonicus* is a very peculiar species of *Marasmius*. It is very well characterized by the bright coloration, predominantly purple with white and cream-colored dots covering the entire pileus surface (Fig. 1). When compared to a description by Singer (1976), the specimens studied here differ in the umbonate pileus shape, corroborating Henning's original description, in contrast to the Bolivian species, described by Singer as umbilicate. Color photos of this species can be found at the website: http://www.cb.ufrn.br/atlasvirtual/Marasmius%20amazonicus.htm.

The neotype was collected in Atlantic Forest remnants, though several studies proved its connectivity with Amazon Rainforest during the Tertiary and Quaternary periods, a fact that could explain their high similarity (Prance 1987). Despite some expeditions to collect *M. amazonicus* in its original location, Amazonian Rainforest, it was not possible to get any exemplar. The main reason for choosing these Brazilian specimens instead of those from the Singer collection, originating in Bolivia, was the advantage of being able to describe the neotype from fresh, higher quality specimens that offered better visualization of various important taxonomic features of the group, such as the color pattern of the pileus, the basal mycelium and the most fragile microstructures, which are more easily visualized in recent material. Thus, we propose to establish the neotype, collected in the Parque Estadual Dunas de Natal, in the state of Rio Grande do Norte, on the coast of Northeast Brazil.

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Ochrolechia pallentiisidiata, a new species from China

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Abstract — A new species of the lichen genus *Ochrolechia*, *O. pallentiisidiata* is described from China. It is characterized by knobby-verrucose isidiata, having heavily white pruinose apothecia, large ascospores and only apothecial margin KC+ red. The species is collected from Yunnan Province in China.

Key words — taxonomy, lichenized ascomycetes, *Ochrolechiaceae*

Introduction

During a study of the lichen family *Ochrolechiaceae* (*Pertusariales*, *Ascomycota*) in China, an epiphloedal species new to science was found. The species differs to other isidiate species in having a larger ascospores and heavily white pruinose apothecia.

Material and methods

The specimens examined collected from China are preserved in the Lichen Section of Herbarium Mycologicum Instituti Microbiological Academine Sinicae (HMAS-L).

For the morphological and anatomical observations were made using a dissecting microscope (TECK-XTS) and a compound microscope (OLYMPUS-CHB) for all materials. Hand-sections were routinely made and examined with water used as the mounting medium. Chemical substances were studied by the color tests with 10% KOH (K), sodium hypochlorite (C) and alcoholic solution of *p*-phenylenediamine (PD), and means of thin-layer chromatography (Culberson & Kristensson 1970, Culberson 1972).

# Ze-Feng JIA and Qiang REN contributed equally to this work

* Corresponding author

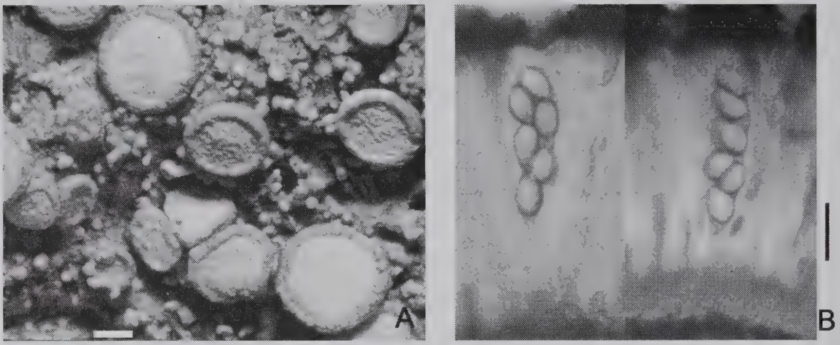

Fig. 1 *Ochrolechia pallentiisidiata.*
A. Habit (bar = 1 mm); B. Two asci containing ascospores (Bar=100μm)

Taxonomic description

Ochrolechia pallentiisidiata Z.F. Jia & Q. Ren, **sp. nov.** Figure 1

MycoBank MB 512228

Similis Ochrolechia pallescens *sed isidiosus, acidum gyrophoricum cotinenti et ascosporis majoribus differt.*

Typus: CHINA, Yunnan Provincia, Weixi, Yezhi, Baimaluo, alt. 2400m, *Jing-Jun Su 0241*, 8.v.1982; holotype: HMAS–L.

Etymology: The specific epithet *pallentiisidiata* is derived from the Latin participle *pallens*, meaning pale, referring to the white pruinose apothecial disks; and the adjective *isidiatus* referring to the isidiate thallus.

Thallus crustose, adnate, up to 1.0 mm thick, becoming thin at edge; grey to dark grey, rough, verruculose to verrucose; knobby to verrucose isidia, the isidium 0.2–0.4 mm across and up to 0.8 mm long, sometimes growing large, concolorous with the thallus. Apothecia sessile, dispersed, roundish, dish-shaped, 1–3 mm in diameter; discs pinkish to orange–pinkish when young, then heavily white pruinose on surface when mature, slightly concave to plane; apothecial margin entire, smooth to verrucose, but not isidiate, 250–400 μm thick, concolorous with the thallus.

Apothecial anatomy: Hymenium hyaline, 300–350 μm high; epithecium brown, 20–40 μm thick; hypothecium slightly brownish, 50–70 μm; paraphyses dense and netted, 1.5–2.0 μm wide; excipulum proprium absent; amphithecium moderately thick, well–developed medulla; cortex 30–50 μm laterally, expanding to over 150 μm at base; algal layer usually forming a continuous layer below hypothecium, scattered to margin. Asci long claviform, 6–8 spores per ascus; ascospores hyaline, simple, ellipsoid to broadly ellipsoid, 70–85 × 37.5–45 μm.

Chemistry: Thallus cortex and medulla K–, C–, KC–, PD–; apothecial disc and margins K–, C+ red or C–, KC+ red, PD+; UV–; containing gyrophoric acid (major) and lecanoric acid.

Table 1. Comparision of *Ochrolechia pallentiisidiata* with similar species

Species	*pallentiisidiata*	*pallescens*	*yasudae*	*isidiata*	*subisidiata*	*antillarum*	*akagiensis*
Thallus	Corticolous	Corticolous	Corticolous & saxicolous	Corticolous	Corticolous	Corticolous	Moss
Isidia	Knobby to verrucose	–	Thick, knobby, persistent	Slender, persistent,	Knobby to granular	Pseudoisidia =granular	Slender, knobby to granular
Apothecia	Concave to plane	Plane to convex	Plane	Plane	Plane	Concave to plane	Concave to plane
Diam. (mm)	1.0–3.0	1.0–3.0(–4.0)	1.0–3.0	1.0–3.0	1.5–2.5	0.9–2.0(–3.0)	1.5–1.0
Pruina	Heavily white pruinose	White pruinose	Slightly pruinose	Epruinose	Pruinose	Lightly pruinose	Epruinose
Ascospores (µm)	70–85 × 37.5–45	48–63 × 20–30	31–61 × 25–34	27–44 × 12–24	24–37 × 14–19	44–61 × 20–34	58–71 × 20–27
C reaction							
Cortex	+	–	+	+	–	+ or –	+
medulla	–	–	–	+	+	+	–
Chemistry							
Gyrophoric acid	+	–	+	+	+	+	+
Lecanoric acid	+	–	+	+	+	+	–
Variotaric acid	–	+	–	–	+	–	–
Lichexanthone	–	–	–	+	–	–	–

Symbols: + =present or positive, – =absent or negative.

Habitat and distribution: The species is so far known only from the type locality where it grows on the bark at the base of *Abies fabri* (Mast.) Craib, Yunnan Province, southern China.

Ochrolechia pallentiisidiata is characterized by having knobby to verrucose isidia, large apothecia 1–3 mm in diam., disks covering white pruinose, asci 6–8-spored, large ascospores 70–85 × 37.5–45 µm and mainly present gyrophoric acid. It is similar to *O. pallescens* (L.) A. Massal. in thallus and white pruinose apothecia, but differs in having isidia, larger ascospores and chemistry (Verseghy 1962). The new species also differs from other isidiate species in having larger ascospores and somewhat different isidia and chemistry (Verseghy 1962, Howard 1970, Brodo 1991, Hanko et al. 1986). The diagnostic features of the species and similar species are summarized in table 1.

Additional material examined: CHINA. Yunnan Province, Weixi, Weideng, Xinhua, alt. 320m, *Jing-Jun Su 0805*, 24.v.1982.

Acknowledgments

The authors thank Prof A. Aptroot and X.G. Zhang for pre-submission reviews. This project was supported by the National Natural Science Foundation of China (No. 30470003).

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MYCOTAXON

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Kretzschmaria albogrisea sp. nov. and *K. curvirima* from Brazil

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Abstract — *Kretzschmaria albogrisea* is described as a new species. It is distinguished primarily by its white and gray surface of the stroma, which has an unusual shape and size. Occurrence of *K. curvirima* in Brazil is reported.

Key words — systematics, *Xylariaceae*, *Ascomycota*

Introduction

Kretzschmaria is a genus of *Xylariaceae* whose species are mainly found in tropical and subtropical regions. Rogers & Ju (1998) accepted 16 taxa. Later, the following taxa were included: *K. orientalis* Lar.N. Vassiljeva, *K. argentinensis* Hladki & A.I. Romero, *K. sigmoidirima* Hladki & A.I. Romero and *K. varians* J.D. Rogers & Y.M. Ju, (Vassiljeva 1998, Hladki & Romero 2001, Rogers & Ju 2004).

In Brazil, *K. cetrarioides* (Welw. & Curr.) Sacc., *K. clavus* (Fr.) Sacc., *K. lucidula* (Mont.) Dennis, *K. micropus* (Fr.) Sacc., *K. pavimentosa* (Ces.) P.M.D. Martin, *K. sandvicensis* (Reichardt) J.D. Rogers & Y.M. Ju and *K. sigmoidirima* have already been reported (Theissen 1908, Sampaio 1916, Chardón et al. 1940, Viégas 1945, Dennis 1957, Batista et al. 1966, Batista & Peres 1967, Silveira & Rodrigues 1985, Rogers & Ju 1998, Hladki & Romero 2003, de Meijer 2006).

In this work we are proposing a new species of *Kretzschmaria* and reporting the occurrence of *K. curvirima* in Brazil.

Materials and methods

On May 2008, a specimen of *Kretzschmaria* was collected in the "Reserva Particular do Patrimônio Natural Fazenda Santa Beatriz do Carnijó", an area of Atlantic Rain Forest in the municipality of Moreno, State of Pernambuco, Brazil. Asci and ascospores were observed in water and Melzer's reagent and analyzed according to Rogers & Ju (1998). Attempts to culture this fungus failed. The exsiccate was deposited in the mycological collection of the URM Herbarium and the description registered in the MycoBank.

A specimen of *K. curvirima* from Amazonas, deposited in the URM Herbarium, was also examined.

Taxonomy

Kretzschmaria albogrisea Jad. Pereira, J.L. Bezerra & L.C. Maia, **sp. nov.** FIGS. 1–5
MycoBank MB512104

Stromata superficialia, solitaria vel gregaria, subglobosa vel hemisphaerica, usque ad 10 mm lata × 2.5–4.5 mm alta; extus alba et grisea, dura, levis; intus alba, mollia. Perithecia subglobosa, 0.4–1 mm lata × 0.6–1 alta. Ostiola leviter elevata. Asci octospori, 245–312 µm longitudine tota × 10–11 µm crassi, partibus sporiferis 175–217 µm longitudine, annulo apicali in liquore iodato Melzeri cyanescente, plus minusve cylindraceo, 10–11 µm alto × 5–5.5 µm lato. Ascosporae fuscae, ellipsoideae vel oblongae, plus minusve inequilaterales, levis, 31–37 × 9–13 µm, rima germinativa recta longa vel brevi praeditae.

ETYMOLOGY: referring to the coloration of the stromatal surface.

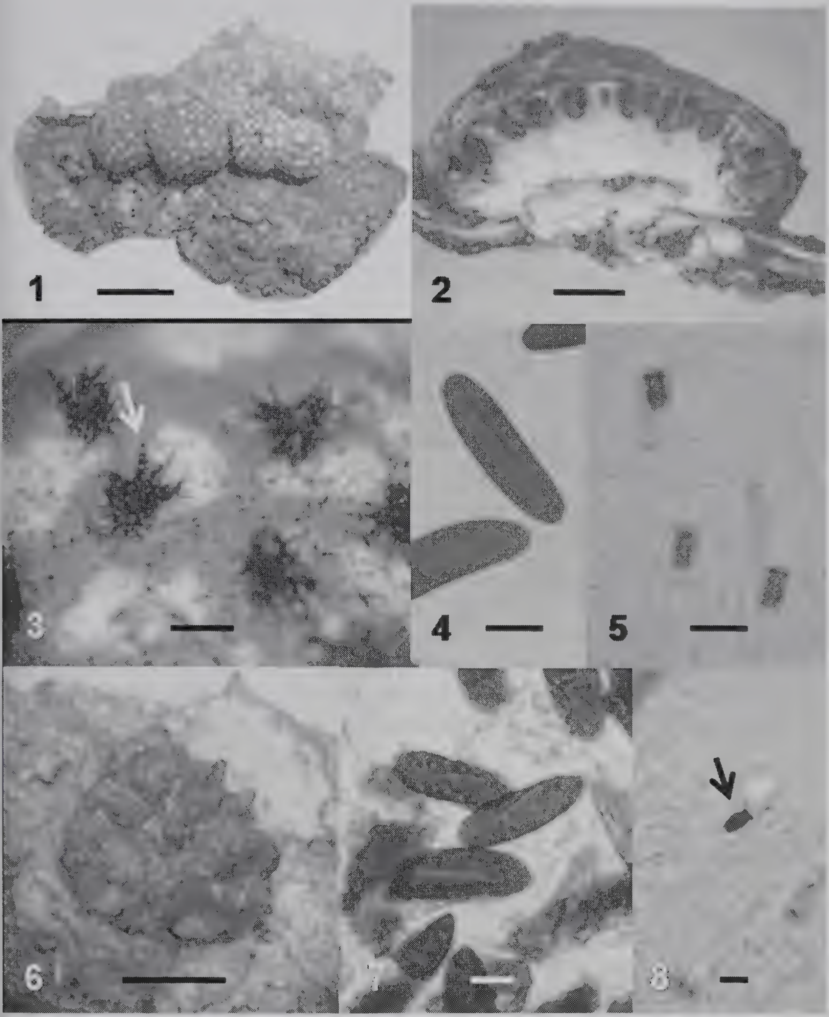
Stromata superficial, solitary or gregarious, subglobose, depressed-spherical to hemispherical, 3.5–10 mm diam × 2.5–4.5 mm high; tissue between and beneath perithecia spongy, white; surface hard, white and gray with mottled aspect. Perithecia spherical to obovoid, 0.4–1 mm diam × 0.6–1 mm high. Ostioles papillate. Asci 8-spored, 245–312 µm total length × 10–11 µm broad, spore-bearing part 175–217 µm long, with the apical ring bluing in Melzer's iodine reagent, urn-shaped, 10–11 µm high, 5–5.5 µm broad. Ascospores uniseriate, blackish brown, ellipsoid, more or less inequilateral, smooth, 31–37 × 9–13 µm, with straight germ slit spore-length to slightly less.

SPECIMEN EXAMINED: BRAZIL: Pernambuco, Moreno, Reserva Particular do Patrimônio Natural Fazenda Santa Beatriz do Carnijó (08°08'38.9"S and 35°04'35.3"W, 120m alt.), 13.V.2008, leg. Jad. Pereira, in bark of indeterminated tree (HOLOTYPE, URM 79233).

Notes: *Kretzschmaria albogrisea* differs from all species of the genus by the sessile stroma with white and gray surface. The species *K. micropus* has similar straight germ slit and ascospore size, but presented blackish brown stromata covered with spines and conical ostioles (Rogers & Ju 1998). Although *K. macrosperma* has straight germ slits and a similar format of ascospores, it differs from *K. albogrisea* by its large ascospores (45–67 × 12.5–17.5 µm) and different stroma.

Kretzschmaria curvirima J.D. Rogers & Y.M. Ju, Mycotaxon 68: 355. 1998.
FIGS. 6–8

Stromata carbonaceous with convex, obconical fertile parts 4.5–6.5 × 4–5.2 mm diam, 1.9–4.3 mm high, containing one or two perithecia, aggregated or



Figs. 1–5: *Kretzschmaria albogrisea*. **1**. Stromata. **2**. Perithecia. **3**. Ascospores released from the Ostioles (arrow). **4**. Ascospore with straight germ slit slightly smaller than spore-length. **5**. Ascus apical ring colored in Melzer's reagent. **6–8:** *Kretzschmaria curvirima*. **6**. Stroma. **7**. Ascospores with sigmoid germ slit. **8**. Ascus apical ring colored in Melzer's reagent (arrow).
Scale bars: 1 = 4 mm; 2 = 2 mm; 3 = 200 µm ; 6 = 3 mm; 4, 5, 7, 8 = 10 µm.

solitary, bearing one to several conic spines on top; surface dull blackish brown; tissue between and beneath perithecia coriaceous, white to gray, becoming dark brown and disintegrating. Perithecia obovoid, 0.5–2 mm diam × 0.9–1.7 mm high. Ostioles conical. Asci damaged, with the apical ring bluing in Melzer's reagent, urn-shaped, 10–10.5 μm high, 5–5.5 μm broad. Ascospores dark brown, unicellular, ellipsoid-inequilateral, with narrowly to broadly rounded ends sometimes pinched, smooth, (35.5–)36–50 × (8–)8.5–16 μm, with sigmoid to spiral germ slit slightly smaller than spore-length.

Specimen Examined: BRAZIL: Amazonas, Manaus, Reserva Ducke, 25.III.1961, leg. G. E. P. Peres, on wood (URM 21237, as *Kretzschmaria spinifera*).

Notes: Rogers & Ju (1998) and Hladki & Romero (2001) reported, respectively, *K. curvirima* and *K. sigmoidirima* with sigmoid and spiral ascospore germ slit. The specimen examined in this work presented similar characters to *K. curvirima*, differing from *K. sigmoidirima* by the presence of conic spines in the stromata and larger ascospores. Batista and co-workers identified this specimen as *K. spinifera* but did not report in their papers. Viégas (1945) reported a specimen correctly identified by Julian H. Miller as *K. spinifera* (= *K. micropus*) in the State of São Paulo.

Acknowledgments

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Biogeography and hosts of poroid wood decay fungi in North Carolina: species of *Trametes* and *Trichaptum*

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Abstract—Distribution and host plants are provided for seven species of *Trametes* and six species of *Trichaptum*. Twenty three of the host-fungus combinations reported here are new records for the United States. County distribution maps are provided for each species as well. The complete checklist can be found at:
www.cals.ncsu.edu/plantpath/people/faculty/grand/projects/mycotaxon_6.pdf

Keywords—fungus distribution, polypores

Introduction

Previous studies by Grand & Vernia (2004a,b) addressed the importance of biodiversity and biogeography of fungi in ecosystems of North Carolina. The occurrence of selected genera and host plants of poroid wood decay fungi in North Carolina have been reported by Jung (1987), Vernia & Grand (2000) and Grand & Vernia (2002, 2005a,b, 2007). These studies have expanded the geographical range and host plant associations of poroid wood decay fungi in the southern region of the United States. This report is the sixth in a series in a long-term study of poroid wood decay fungi in North Carolina.

Materials and methods

Poroid wood decay fungi were collected in North Carolina from 1997-2007. Collections were made of all species of *Trametes* and *Trichaptum* on new or unusual hosts. Specimens were placed in paper bags in the field with a sample of decayed wood for the majority of collections and field notes for all collections. Specimens were examined in the laboratory and identified using the taxonomic treatments of Gilbertson & Ryvarden (1987), Jung (1987) and Overholts (1953). Nomenclature and authorities are from Index Fungorum (CABI et al. 2007) for fungi and Kartesz (1994) and IPNI (2007) for host plants.

The majority of collection sites were in state parks, game lands and natural areas, the Nantahala, Pisgah, Croatan and Uwharrie National Forests and the Blue Ridge Parkway and Great Smoky Mountains National Parks. A county distribution map is provided for each species (Figs. 1–12).

Data from previous studies (Jung 1987, Grand et al. 1975), collections in the mycological herbarium (NCSC) at North Carolina State University (NCSU) and the University of Tennessee Mycological Herbarium (Ma & Petersen 2007), records of the Plant Disease and Insect Clinic, Plant Pathology Department, NCSU, and the BPI web site (Farr et al. n.d.) were used in developing distribution maps.

Results and Discussion

Seven species of *Trametes* were recorded. *Trametes elegans* (Spreng.) Fr. (Fig. 3), *T. hirsuta* (Wulfen) Pilát (Fig. 4), and *T. versicolor* (L.) Lloyd (Fig. 6) are common and widespread throughout North Carolina. The limited distribution of *T. conchifera* (Schwein.) Pilát (Fig. 2) does not reflect the statewide distribution of its most common host, elm (*Ulmus* spp.). One would expect *T. conchifera* to be more widespread throughout the state. *Trametes pubescens* (Schumach.) Pilát (Fig. 5) was recorded from 13 counties in all three physiographic provinces. *Trametes cervina* (Schwein.) Bres. (Fig. 1) and *T. villosa* (Sw.) Kreisel (Fig. 7) were not collected frequently enough to determine a distribution pattern.

Six species of *Trichaptum* were recorded. *Trichaptum abietinum* (Pers.) Ryvarden (Fig. 8) and *T. biforme* (Fr.) Ryvarden (Fig. 9) are widespread in North Carolina. *Trichaptum abietinum* occurs only on conifers, and *T. biforme* occurs almost exclusively on deciduous trees. *Trichaptum fuscoviolaceum* (Ehrenb.) Ryvarden (Fig. 11) was found in nine counties in all three physiographic provinces. *Trichaptum byssogenum* (Jungh.) Ryvarden (Fig. 10) and *T. laricinum* (P. Karst.) Ryvarden (Fig. 12) were not collected frequently enough to determine a distribution pattern. *Trichaptum sector* (Ehrenb.) Kreisel (Fig. 12) was found in nine counties in the Coastal Plain. It is typically a southeastern species (Gilberston & Ryvarden 1987) and may reach the northern limits of its range in North Carolina.

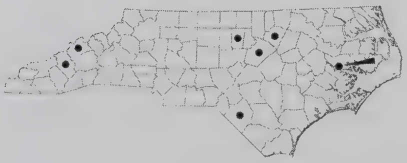

Fig. 1. Distribution of *Trametes cervina* in North Carolina.

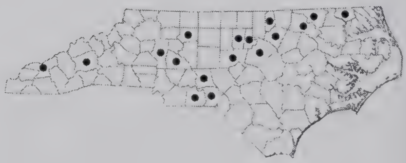

Fig. 2. Distribution of *Trametes conchifera* in North Carolina.

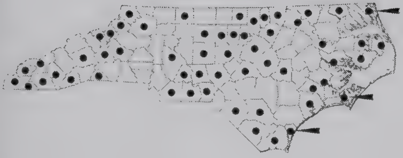

Fig. 3. Distribution of *Trametes elegans* in North Carolina.

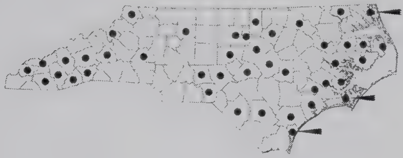

Fig. 4. Distribution of *Trametes hirsuta* in North Carolina.

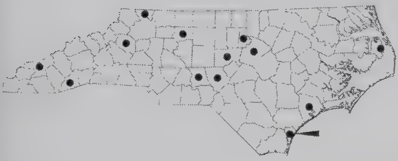

Fig. 5. Distribution of *Trametes pubescens* in North Carolina.

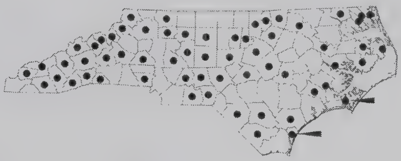

Fig. 6. Distribution of *Trametes versicolor* in North Carolina.

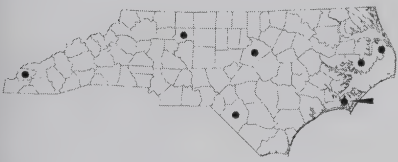

Fig. 7. Distribution of *Trametes villosa* in North Carolina.

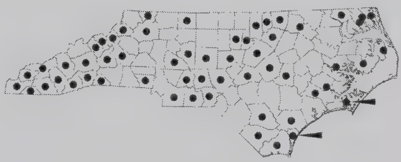

Fig. 8. Distribution of *Trichaptum abietinum* in North Carolina.

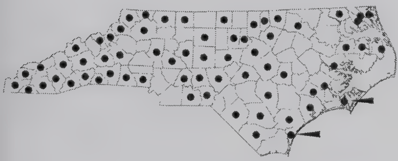

Fig. 9. Distribution of *Trichaptum biforme* in North Carolina.

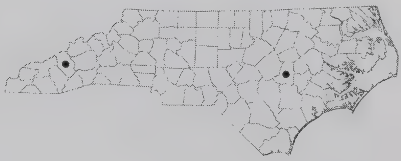

Fig. 10. Distribution of *Trichaptum byssogenum* in North Carolina.

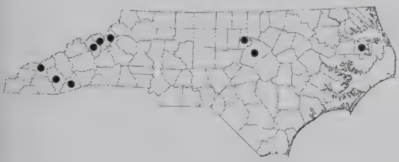

Fig. 11. Distribution of *Trichaptum fuscoviolaceum* in North Carolina.

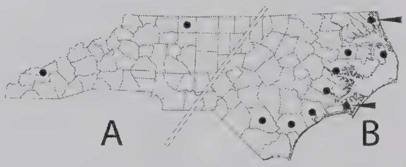

Fig. 12. Distribution of (A) *Trichaptum laricinum* and (B) *T. sector* in North Carolina.

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Glomus irregulare, a new arbuscular mycorrhizal fungus in the *Glomeromycota*

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Abstract — A new arbuscular mycorrhizal fungus (*Glomeromycota*) is described and illustrated. *Glomus irregulare* was found associated with different plants colonizing maritime sand dunes of Giftung Island, Egypt (Africa), Bornholm (Denmark), Greece, Poland, and Spain. This fungus produces spores aggregated inside roots or in the soil or (rarely) singly in the soil. Spores form blastically either (when aggregated) at the tip of or along dichotomously branched hyphae continuous with mycorrhizal extraradical hyphae or (when single) terminally from the unbranched extraradical hyphae. The hyaline to pale yellow spores are ovoid, oblong to irregular, 60–130 × 80–240 μm, and may have deep wall depressions and apical cap-like swellings. The spore wall consists of two semi-permanent, hyaline outer layers and a hyaline to pale yellow, laminate innermost layer staining in Melzer's reagent. *Glomus irregulare* formed vesicular-arbuscular mycorrhizae in single-species cultures with *Plantago lanceolata* as the host plant. Phylogenetic analyses do not yet conclusively support the obvious morphological and biochemical differences between *G. irregulare* and *G. intraradices*, and the need to sequence other rDNA regions to further refine genetic relationships is suggested.

Key words — distribution, molecular phylogeny

Introduction

Arbuscular mycorrhizal fungi (AMF), which are believed to have evolved over 450 million years ago, associate with most vascular land plants and have a worldwide distribution (Redecker et al. 2000, Smith & Read 1997). Among the many beneficial effects of the symbiosis between AMF and plants are the increased productivity and strength of mycorrhizal plants and the positive influence of these fungi on plant biodiversity (Smith & Read 1997, van der Heijden et al. 1998).

For many years, AMF were placed in phylum *Zygomycota*, first in the family *Endogonaceae* Paol. of the order *Endogonales* Moreau (Gerdemann & Trappe 1974, Morton & Benny 1990a), and then in the order *Glomerales* J.B. Morton & Benny (Morton & Benny 1990a). However, molecular analyses have revealed that these fungi have no affinity with either members of the *Zygomycota* or other known major fungal groups (Schüβler et al. 2001). Consequently, they were removed from the *Zygomycota* to be accommodated in a new phylum, the *Glomeromycota* C. Walker & A. Schüssler, presently comprising four orders, ten families, and fourteen genera (Błaszkowski 2003, Oehl & Sieverding 2004, Palenzuela et al. 2008, Schüβler et al. 2001, Sieverding & Oehl 2006, Walker & A. Schüssler 2004, Walker et al. 2007a, b, 2008).

The most numerous and diverse fungal group in the *Glomeromycota* is the genus *Glomus* Tul. & C. Tul., comprising ca. 53% of all arbuscular fungi described to date. Within *Glomus,* Schwarzott et al. (2001) established three phylogenetic groups, *Glomus* groups A, B, and C. Walker & Schüβler (2004) elevated *Glomus* group C to the rank of genus, *Diversispora* C. Walker & A. Schüssler, in the newly erected family *Diversisporaceae* C. Walker & A. Schüssler and order *Diversisporales* C. Walker & A. Schüssler. The *Diversisporales* now includes four additional families, the *Acaulosporaceae* J.B. Morton & Benny, *Entrophosporaceae* Oehl & Sieverd., *Gigasporaceae* J.B. Morton & Benny, and *Pacisporaceae* C. Walker et al. (Błaszkowski 2003, Schüβler & Walker 2004, Sieverding & Oehl 2006). Whereas *Glomus* group B was phylogenetically uniform, *Glomus* group A contained two or three subclades (a–c), with subclade "c" including only one undescribed *Glomus* sp. isolate (W3347; Schwarzott et al. 2001) to which many other sequences have been added (Kovács et al. 2007). Representatives of the other subclades include *G. mosseae* (T.H. Nicolson & Gerd.) Gerd. & Trappe (subclade "a") and *G. intraradices* N.C. Schenck & G.S. Sm. (subclade "b")

Apart from interspecific genetic differences, AMF also exhibit intraspecific divergences, especially within *Glomeraceae* Piroz. & Dalpé. Antoniolli et al. (2000) found a 3–5-fold higher genetic diversity within *G. mosseae* spores than in *Gigaspora margarita* W.N. Becker & I.R. Hall that was isolated from the same site. Jansa et al. (2002), who analyzed intra- and intersporal diversity using the internal transcribed spacer (ITS) of ribosomal DNA sequences from three *G. intraradices* isolates, revealed two different sequence types within a single-spore isolate. Moreover, phylogenetic analyses of all sequences known at that time, including those deposited in GenBank, showed four distinct ITS sequence types for *G. intraradices*.

Investigations of AMF occurrence in rhizosphere soil and root samples collected from different regions in Europe revealed a frequent irregularly-shaped *Glomus* spore with a morphology unlike that found in any other described *Glomus* species. Although this fungus tended to form intraradical spores similar to *G. intraradices* and its extraradical globose spores superficially resembled those from lighter-coloured isolates of the latter fungus, marked differences mainly in (1) the mode of spore formation, (2) aggregated spore organization, and (3) the phenotypic and biochemical properties of their spore wall components convinced us that these fungi are morphologically distinct. Therefore, the newly discovered *Glomus* morphotype is described below as *G. irregulare* sp. nov. Phylogenetic analyses of sequences from *G. irregulare* spores, however, indicate that they partly cluster with *G. intraradices* sequences. The contradiction between the morphological and molecular analyses of *Glomus irregulare* and *G. intraradices* is discussed in detail below.

Materials and methods

Establishment and growth of trap and single-species cultures, extraction of spores, and staining of mycorrhizae

Spores examined in this study came from both pot trap and single-species cultures. Trap cultures were established to obtain a great number of living spores and to initiate sporulation of species that were present but not sporulating in the field collections (Stutz & Morton 1996). The method used to establish trap cultures, their growing conditions, and the methods of spore extraction and staining of mycorrhizae were as those described previously (Błaszkowski et al. 2006).

Single-species cultures were also generally established and grown as given in Błaszkowski et al. (2006), with two exceptions. First, instead of marine sand, their growing medium was an autoclaved commercially available coarse-grained sand (grains 1.0–10.0 mm diam – 80.50%; grains 0.1–1.0 mm diam – 17.28%; grains < 0.1 mm diam – 2.22%) mixed (5:1, v/v) with clinopthilolite (Zeocem, Bystré, Slovakia) of grains 2.5–5 mm. Clinopthilolite is a crystalline hydrated alumosilicate of alkali metals and alkaline earth metals having, e.g., a high ion exchange capability and selectivity, as well as a reversible hydration and dehydration. pH of the sand-clinopthilolite mixture was 7.3. Second, the cultures were kept in transparent plastic bags, 15 cm wide and 22 cm high as suggested by Walker & Vestberg (1994), rather than open pot cultures (Gilmore 1968). To prevent contamination of the cultures with other AMF but still to allow exchange of gases, we left an opening, about 1 cm wide, in the centre of the upper part of each bag, while the edges on both sides were closed with small plastic clips. The cultures were watered with tap water once a weak, harvested after five months when spores were extracted for study. To reveal mycorrhizae, root fragments located ca. 1–5 cm below the upper level of the growing medium were cut off with a scalpel. *Plantago lanceolata* was the host plant used in both trap and single-species cultures.

Microscopy survey

Morphological properties of spores and their wall structure were determined based on examination of at least 100 spores mounted in polyvinyl alcohol/lactic acid/glycerol (PVLG; Omar et al. 1979) and a mixture of PVLG and Melzer's reagent (1:1, v/v). Spores at all developmental stages were crushed to varying degrees by applying pressure to the cover slip and then stored at 65°C for 24 h to clear their contents from oil droplets. They were then examined under an Olympus BX 50 compound microscope equipped with Nomarski differential interference contrast optics. Microphotographs were recorded on a Sony 3CDD color video camera coupled to the microscope.

Terminology of spore structure is that suggested by Stürmer & Morton (1997) and Walker (1983). Spore colour was examined under a dissecting microscope on fresh specimens immersed in water. Colour names are from Kornerup & Wanscher (1983). Nomenclature of fungi and plants is that of Walker & Trappe (1993) and Mirek et al. (1995), respectively. The authors of the fungal names are those presented at the Index Fungorum website http://www.indexfungorum.org/AuthorsOfFungalNames.htm. Voucher specimens were mounted in PVLG and a mixture of PVLG and Melzer's reagent (1:1, v/v) on slides and deposited in the Department of Plant Protection, University of Agriculture, Szczecin, Poland, and in the herbarium at Oregon State University (OSC) in Corvallis, Oregon, U.S.A.

Colour microphotographs of spores of *G. irregulare* can be viewed at the URL http://www.agro.ar.szczecin.pl/~jblaszkowski/.

Spore cleaning and DNA extraction

Spores of *G. intraradices*, *G. irregulare*, and *G. geosporum* (the last species selected to represent an outgroup in phylogenetic analyses) used in the molecular analyses were isolated from single-species cultures established from spores produced in trap cultures with mixtures of the rhizosphere soil and root fragments of *Ammophila arenaria* (L.) Link growing in maritime dunes of Bornholm, Denmark. Spores were separated in a Petri dish with fresh and autoclaved double distilled water using a pipette. Spores (ca. 10) were transferred to 1.5 ml reaction tubes and cleaned by washing in sterile filtered SDS (1%) and rinsing twice with fresh double distilled water followed by washing in absolute ethanol. The tubes were air dried under the clean bench and kept at -20°C until DNA extraction. Spore DNA was extracted following the procedure described by Manian et al. (2001). The samples were frozen in liquid nitrogen in 1.5 ml tubes and crushed thoroughly using a micropestle. To each sample, 100 µl of lysis buffer (200 mM TrisHCl pH 7.5, 250 mM NaCl, 1 mM EDTA and 1% SDS, w/v) was added and mixed thoroughly. The samples were subjected to three alternate cycles of freezing in liquid nitrogen and incubation at 100°C for 1 min, followed by freezing and a final incubation at 100°C for 10 min. The contents of each tube were centrifuged at 11 000 *g* for 3 min and the supernatant collected carefully. The supernatants were passed through DNA purification columns (QIAquick, Qiagen) according to the manufacturer's instructions. The purified DNA was eluted in 50 µl of 1 mM TrisHCl pH 8.5 prewarmed to 55°C.

PCR amplification

The nuclear ribosomal SSU and ITS rDNA genes were amplified with two parallel nested PCR reactions. Partial SSU rDNA was amplified using the primer pair

GlomerWT0 (5'-CGA TGD WTC ATT CAA ATT TCT GCC -3') and Glomer1536 (5'-RTT GCA ATG CTC TAT CCC CA-3') in the first PCR amplification and GlomerWT0 and GlomerWT2 (5'-CAA ACT TCC ATC GGT TAR ACA CCG-3') for the second PCR (Wubet et al. 2006). The end part of the SSU with the complete internal transcribed spacer (ITS) region was amplified using the primer set NS5 (5' -AAC TTA AAG GAA TTG ACG GAA G- 3') and ITS4 (5' –TCC TCC GCT TAT TGA TAT GC- 3') for the first PCR and Glom1310 (5' –AGC TAG GYC TAA CTT TGT TA- 3') and ITS4 for the nested PCR amplification (Redecker 2000). In both steps, DNA was amplified in 50 µl reaction volume containing PCR buffer (Invitrogen, Karlsruhe), concentrations of 0.2 mM of each dNTP (Invitrogen) and 0.5 mM of each primer, 1.5 units of recombinant Taq DNA polymerase (Invitrogen), and 1 µl of DNA template, using the program Touch 60. A 4 µl aliquot of each nested PCR product was analysed on a 1% agarose gel followed by ethidium bromide (0.5 mg/ml) staining and photographed under UV light.

Nested PCR products were purified and cloned using the peqGOLD Cycle-Pure Kit (PEQLAB) and the pCR4-Topo vector system (Invitrogen), respectively. Individual transformed colonies were picked and directly used in a PCR reaction with the M13 forward and M13 reverse primers. Clone check PCR was carried out in 25 cycles (94°C for 1 min, 55°C for 1 min, and 72°C for 1 min). Cloned products were then purified, as described above, and used in cycle sequencing with the M13 PCR primers as sequencing primers using an ABI PRISM Big Dye Terminator Cycle Sequencing Ready Reaction Kit v.3.1 (Applied Biosystems, Warrington, United Kingdom) according to the manufacturer's protocol and data sampling was performed on an automated sequencer (ABI PRISM 3100 Genetic Analyser, Applied Biosystems). Sequence editing and merging using both strand SSU and ITS sequences was done using the BioEdit sequence Alignment Editor (version 7.0.5, http://www.mbio.ncsu.edu/BioEdit/bioedit.html). The sequences have been deposited at GenBank (NCBI, www.ncbi.nlm.nih.gov) under accession numbers FJ009592 - FJ009622.

Phylogenetic analysis

The SSU and ITS nuclear rDNA sequences obtained from *G. intraradices*, *G. irregulare*, and *G. geosporum* were aligned using the program MAFFT (version 6.28, http://align.bmr.kyushu-u.ac.jp/mafft/software/) resulting in a 2050 bp alignment. Phylogenetic analyses were performed with PAUP* version 4.0b10 (Swofford 2002) as follows:

(1) Distance analysis: The BIONJ modification (Gascuel 1997) of neighbor joining (Saitou & Nei 1987) was performed, coupled with 1000 replicates of non-parametric bootstrapping (Felsenstein 1985), using Kimura two-parameter distances as well as genetic distances derived from the general time-reversible model of DNA substitution, additionally accounting for rate heterogeneity among the nucleotide sites and also assuming a certain percentage of invariable sites (GTR+I+G; see Swofford et al. 1996 for details). The individual model parameters were estimated using Modeltest 3.7 (Posada & Crandall 1998).

(2) Maximum likelihood analysis: Maximum likelihood searches were performed using PHYML 2.4 (Guidon & Gascuel 2003) under the GTR evolutionary model starting from a tree obtained using the modified neighbor-joining algorithm BIONJ (Gascuel 1997) together with 1000 replicates of non-parametric bootstrapping.

(3) Maximum parsimony analysis: Parsimony bootstrap values were computed from 1000 bootstrap replicates using heuristic searches with tree bisection-reconnection (TBR) branch swapping from starting trees obtained by subsequent addition of sequences in random order (10 heuristic searches per bootstrap replicate, with multrees and steepest descent options not in effect and gaps treated as missing characters).

(4) Bayesian MCMC analysis: Bayesian MCMC analysis was performed using MrBayes v. 3.1.1 (Ronquist & Huelsenbeck 2003). We ran two independent MCMC analyses each involving two incrementally heated chains over 2 million generations using the GTR+I+G model of nucleotide substitution and starting from random trees. Trees were sampled every 100 generations, resulting in an overall sampling of 20 000 trees per run from which first 2000 trees were discarded (burn in). The remaining trees sampled from each run were pooled and used to compute a majority rule consensus tree to get estimates for the posterior probabilities. MCMC mean values of the model parameters (obtained with Tracer v. 1.2, Rambaut & Drummond 2003) were used to estimate branch lengths of a majority rule consensus of the sampled trees in PAUP* (Swofford 2002) *via* maximum likelihood.

Results

Both *Glomus intraradices* (Figs 24, 25, 29) and the fungus described below as *G. irregulare* (Figs 1–4, 7, 14, 16) formed intraradical and extraradical spores in aggregates and singly in the soil. However, marked differences mainly in (1) the mode of spore formation, (2) spore organization in aggregates, and (3) the phenotypic and biochemical properties of their spore wall components readily separate the two fungi.

Phylogenetic analysis of SSU or ITS rDNA fragments, including sequences from GenBank (data not shown), indicates that *G. irregulare* clusters with *G. intraradices*. Although analysis using only SSU and ITS sequences obtained in this study (Fig. 23) is better resolved, it still does not support convincingly the obvious morphological and biochemical separation of the two fungi (Figs 1–22, 24–31). Therefore, the two fungi are described, illustrated, and compared based on the spore morphologies and biochemical properties. Additionally, the current distribution of *G. irregulare* is presented and its spores are compared with those representing other described *Glomus* spp. of a similar appearance and phylogenetic position.

Glomus irregulare Błaszk., Wubet, Renker & Buscot, sp. nov. Figs 1–23
MycoBank no. MB 512239

Sporocarpia ignota. Sporae singulatim, gregarius in solo vel in radici efformatae. Gregaria plerumque oblongae; 60–130 × 80–240 μm; e sporis 2–4. Sporae hyalinae vel pallide luteae; ovoideae, oblongae, vel irregulares; 60–130 × 80–240 μm, raro globosae vel subglobosae; (70–)83(–100) μm diam; e alte plicatis vel profunde cavitis, 7.5–25.0 altis. Tunica sporae e stratis tribus (strati 1–3); strato "1" caduco, glabro, hyalino, (0.5–)0.8(–1.5) μm crasso; strato "2" caduco, glabro, hyalino, (0.6–)1.8(–5.0) μm crasso; strato "3" laminato, glabro, hyalino vel pallide luteo, (1.5–)2.4(–4.4) μm crasso, in solutione Melzeri rubicoso vel intenso *rufuso. Hypha subtenda hyalina vel pallide lutea; recta vel recurva; fere infundibuliforma, raro cylindrica vel colliga; (6.4–)10.8(–18.9)µm lata ad basim sporae; pariete hyalino vel pallide luteo; (1.5–)3.8(–8.5) µm crasso at basim sporae, stratis 1–3 sporae continuo. Porus apertus vel e septo continuo strati "3" sporae efformata. Vesicular-arbusculares mycorrhizae formans.*

Holotypus. Poland. Szczecin, infra *Plantago lanceolata* L., 17 May 2006, *Błaszkowski,J. 2340* (DPP).

Etymology. Latin, *irregulare* referring to the irregular shape of the fungus spores.

Sporocarps unknown. Spores occur mainly in aggregates inside roots or in the soil (Figs 1–3), rarely singly in the soil (Figs 7, 14); develop blastically mainly either at the tip of (Fig. 4) or intercalary (Figs 5–7) along dichotomously branched coenocytic to sparsely septate hyphae continuous with mycorrhizal extraradical hyphae (when in aggregates), rarely terminally from unbranched mycorrhizal extraradical hyphae (when single). Hyphae bearing spores hyaline, 4.9–13.2 µm wide, with a wall 1.5–3.4 µm thick, composed of three layers continuous with spore wall layers 1–3; hyphal wall layer 3 stains pale orange (6A3) to deep red (10C8) in Melzer's reagent (Fig. 4). The branches of the dichotomously branched hyphae sometimes form secondary dichotomous branches bearing next both terminal and intercalary spores. Aggregates usually oblong; 60–130 × 80–240 µm; with 2 to 6 spores (Figs 2, 3). Spores hyaline to pale yellow (3A3); mostly ovoid to oblong or irregular; 60–130 × 80–240 µm; very rarely globose to subglobose; (70–)83(–100) µm diam; frequently with 7.5–25.0 µm deep depressions, (Figs 1–8); spores with a single subtending hypha (Fig. 4), occasionally with two (Fig. 7). Spore wall structure composed of one wall (Figs 4, 9–14, 16) with three layers (layers 1–3). Outermost layer 1, forming the spore surface, semi-permanent, smooth, hyaline, (0.5–)0.8(–1.5) µm thick before disintegration (Figs 9–13, 16), frequently highly thickened at the top to form a cap-like swelling up to 25 µm high (Fig. 13). Layer 2 semi-permanent, smooth, hyaline, (0.6–)1.8(–5.0) µm thick before disintegration (Figs 9–13, 16). Layers 1 and 2 usually closely adherent to each other, but separable from layer 3 and present as intact (Figs 9–13) or more or less deteriorated structures (Figs 14, 16) in most mature spores. Layer 3 laminate, smooth, hyaline to pale yellow (3A3), (1.5–)2.4(–4.4) µm thick, staining pale orange (6A3) to deep red (10C8) in Melzer's reagent (Figs 9–14, 16). Subtending hypha hyaline to pale yellow (3A3); straight or recurvate, mostly funnel-shaped, rarely cylindrical, flared or constricted; (6.4–)10.8(–18.9) µm wide at the spore base (Figs 10, 14–16). Wall of subtending hypha hyaline to pale yellow (3A3); (1.5–)3.8(–8.5) µm thick at the spore base; continuous with spore wall layers 1–3 (Figs 15, 16) in both young and most mature spores. Pore open in most mature spores (Fig. 16), occasionally occluded by a curved septum (Fig. 15), (3.9–)5.9(–8.6) µm wide, continuous with the innermost lamina of spore wall layer 3. Germination structures not observed.

Mycorrhizal associations. The presence of mycorrhizae in field-collected root fragments of the plant species sampled was not determined.

In single-species cultures with *P. lanceolata* as the host plant, *G. irregulare* mycorrhizae consisted of arbuscules, vesicles, as well as intra- and extraradical hyphae (Figs 17–22). Arbuscules were numerous and evenly dispersed along the root fragment examined. They consisted of short trunks grown from parent hyphae and had many branches with fine tips (Figs 17). Vesicles usually were ovoid to irregular, 30–120 × 60–210 μm, rarely globose, (40–)91(–140) μm diam (Figs 18, 22). Their wall was thin and consisted of one layer. They frequently occurred in aggregates widely dispersed along roots. Intraradical hyphae grew along the root axis, were (2.2–)5.2(–9.8) μm wide, straight or slightly curved, and occasionally formed H- and/or Y-shaped branches and coils (Figs 17, 19–22). The coils were ellipsoid, 17.5–27.5 × 37.5–82.5 μ, when seen in a plane view (Fig. 21). Extraradical hyphae were (3.2–)4.1(–5.6) μm wide and occurred in low abundances (Fig. 22). In 0.1% trypan blue, arbuscules stained pale violet (16A3) to reddish violet (16A7), vesicles pale violet (16A3) to deep violet (16E8), intraradical hyphae pale violet (16A3) to greyish violet (16C6), coils pale violet (16A3) to light lilac (16A5), and extraradical hyphae reddish violet (16A6-7).

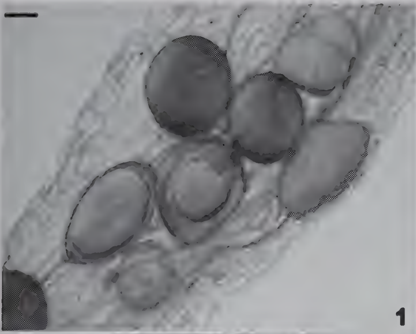
Phylogenetic position. Five phylogenetic analyses of the nuclear SSU and ITS rDNA sequences of spores of *G. irregulare*, *G. intraradices*, and *G. geosporum* (the last serving as outgroup) indicated that, except for two *G. intraradices* sequences that grouped together basal to the *G. irregulare* sequences, the remaining *G. intraradices* sequences formed a separate cluster (Fig. 23).

Specimens examined. Holotype. Poland. Szczecin, under pot-cultured *P. lanceolata*, 17 May 2006, *Błaszkowski J., 2340* (DPP); isotypes: *Błaszkowski J. 2341-2355* (DPP) and two slides at OSC.

Other material examined. AFRICA, Egypt, the Giftung Island, associated with roots of an unknown plant, 20.Aug. 2007, Błaszkowski J., 2949 and 2950 (DPP). DENMARK. Bornholm, in roots of *Ammophila arenaria*, 2 Oct. 2004, Błaszkowski J., 2940-2942 (DPP). GREECE. Veriko, in the rhizosphere of *Xanthium* cf. *spinosum* L., 12 Sept. 1995, Błaszkowski J., 2943 (DPP). ITALY. Calambrone, in roots of *A. arenaria*, 11 Oct. 2002, Błaszkowski J. 2944 (DPP). POLAND. Hel, in roots of *A. arenaria*, 18 July 2000, Błaszkowski J., unnumb. coll. (DPP); Słowiński National Park, associated with roots of *A. arenaria*, 1 April 2004, Błaszkowski J., unnumb. coll. (DPP); Świnoujście, under *Petasites spurius* (Retz.) Rchb., 6 Oct. 1993, Błaszkowski J., unnumb. coll. (DPP). SPAIN. Majorca, El Arenal, associated with roots of *A. arenaria*, 22 Aug. 2001, Błaszkowski J.,

Figs 1–8. Spores of *Glomus irregulare*.(DIC) **1.** Intraradical spores. **2–3.** Extraradical spores in aggregates. **4.** Terminal spore with 3-layered wall (swl1-3) originated from dichotomously branched 3-layered (hwl1-3) hypha. **5–6.** Intercalary spores (is) with short hyphae (h) from which top spores originated. **7.** Intercalary spore with two subtending hyphae (sh). **8.** Depressions (d) of spore wall.

(Figs 1, 4, 7, spores mounted in PVLG+Melzer's reagent; Figs 2, 3, 5, 6, 8, spores mounted in PVLG.) Bars: Figs 4–8 =10 μm; Figs 2—3=20 μm; Fig. 1=50 μm.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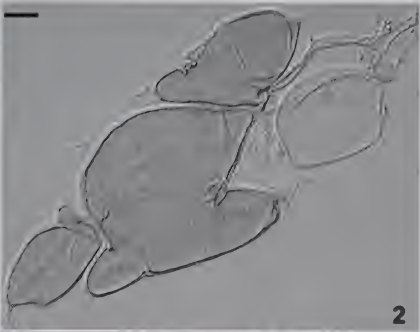
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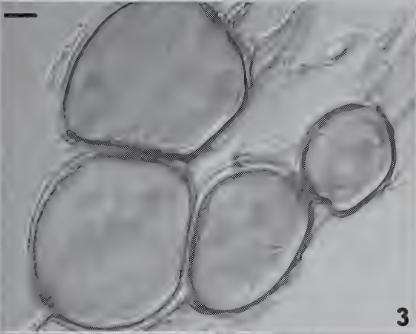
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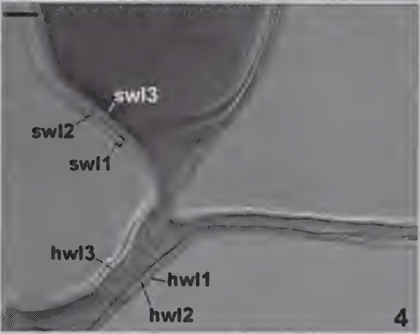
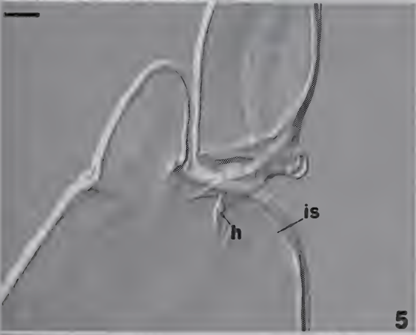

swl3
swl2
swl1
hwl3
hwl1
hwl2
4



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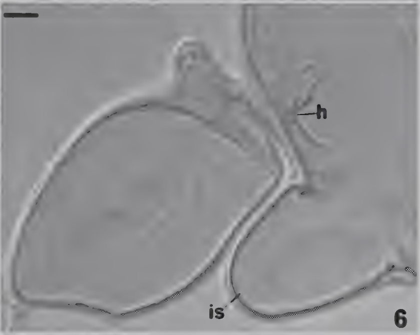

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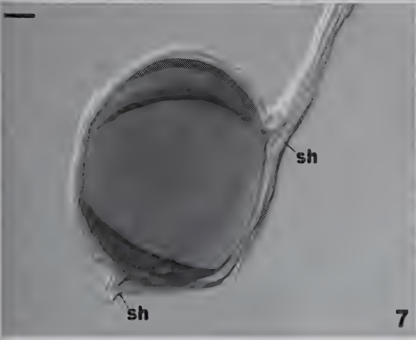

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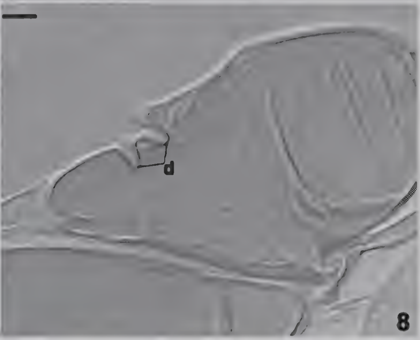

8

2945 (DPP); Cape Salinas, associated with roots of *A. arenaria*, 24 Aug. 2001, Błaszkowski J., 2946-2948 (DPP).

Distribution and habitat. *Glomus irregulare* spores were first found in a field-collected rhizosphere soil of *P. spurius* growing in maritime sand dunes of the Baltic Sea adjacent to Świnoujście (53°55'N, 14°14'E) in north-western Poland in October 1993. The only other field collection of this fungus was made in September 1995 under *Xanthium spinosum* colonizing dunes on the Mediterranean Sea located near Veriko (22°35'E, 40°08'N) in Greece. *Glomus irregulare* spores were also isolated from pot trap cultures with mixtures of rhizosphere soils and *Ammophila arenaria* roots growing in dunes of (1) Bornholm (55°08'N, 14°55'E), Denmark, in October 2004 (133 cultures), (2) the Baltic Sea extending along the Słowiński National Park (54°45'N, 17°26'E) in northern Poland in April 2004 (one culture), (3) the Baltic Sea adjacent to Hel (54°36'N, 18°49'E) in northern Poland in July 2000 (one culture), (4) the Mediterranean Sea near Calambrone (43°35'N, 10°18'E), Italy, in October 2002 (one culture), and (5) the Mediterranean Sea adjacent to El Arenal (39°31'N, 2°45'E) and Cape Salinas (36°19'N, 3°2'E), Majorca, Spain, in August 2001 [three and one culture(s), respectively]. Additionally, *G. irregulare* occurred in a trap culture with a rhizosphere soil and root fragments of an unidentified plant growing in maritime dunes of the Giftung Island (27°11'N, 33°58'E), Egypt, Africa, in August 2007.

In Poland, the species of arbuscular fungi co-occurring with *G. irregulare* in the field were *Entrophospora baltica* Błaszk. et al. and *G. corymbiforme* Błaszk., and in the trap cultures *Scutellospora dipurpurescens* J.B. Morton & Koske. In the field soil sample collected in Greece, *G. irregulare* accompanied *G. xanthium* Błaszk. et al., an unrecognized *Glomus* sp., and *S. persica* (Koske & C. Walker) C. Walker & F.E. Sanders. The cultures with soils of Bornholm still contained spores of *Acaulospora mellea* Spain & N.C. Schenck, *Archaeospora trappei* R.N. Ames & Linderman) J.B. Morton & D. Redecker emend. Spain, *G. aggregatum* N.C. Schenck & G.S. Sm. emend. Koske, *G. constrictum* Trappe, *G. drummondii* Błaszk. & Renker, *G. eburneum* L.J. Kenn. et al., *G. fasciculatum* (Thaxt.) Gerd. & Trappe emend. C. Walker & Koske, *G. intraradices*, *G. mosseae*, *G. pustulatum* Koske et al., undescribed *Glomus* spp. isolates 178 and 204, *Paraglomus laccatum* (Błaszk.) Renker et al., and *S. dipurpurescens*. In cultures with soils of Italy,

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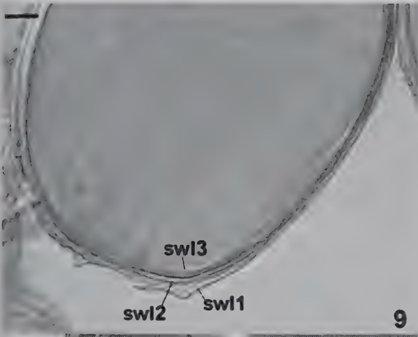
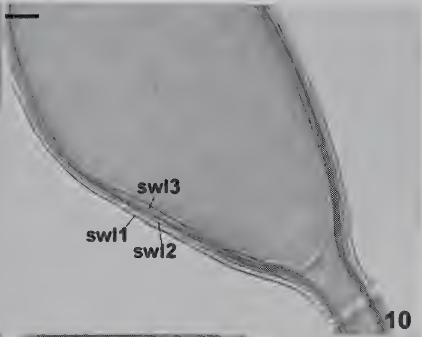
Figs 9–16. Spores of *Glomus irregulare*. (DIC) **9–12.** Intact three layers of spore wall (swl1-3). **13.** Intact three layers of spore wall with top cap-like swell (sl) of layer 1. **14.** Highly deteriorated layers 1 and 2 (swl1 and 2) and layer 3 of irregular spore with one subtending hypha (sh). **15.** Three layers of subtending hypha (shwl1-3) occluded by curved septum (s). **16.** Subtending hyphal wall layers 1–3 (shwl1-3) continuous with spore wall layers 1–3 (swl1-3).

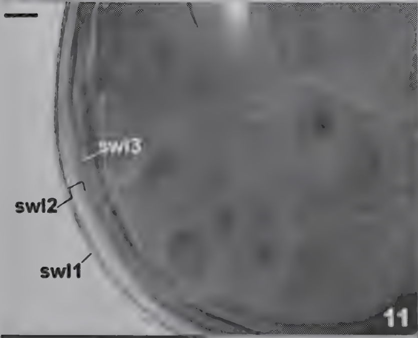
(Figs 11–14, 16, spores mounted in PVLG+Melzer's reagent; Figs 10, 15, spores mounted in PVLG.) Bar =10 μm.


swl3
swl2
swl1

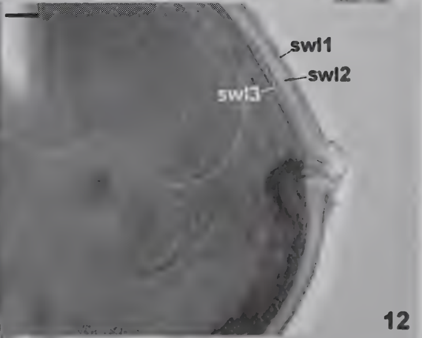
9


swl3
swl1
swl2

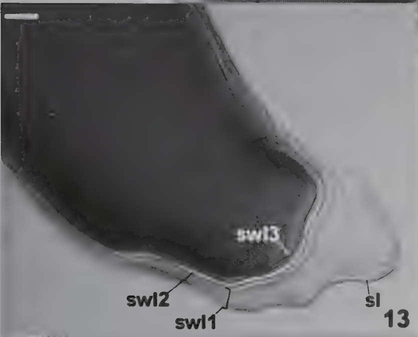
10


swl3
swl2
swl1

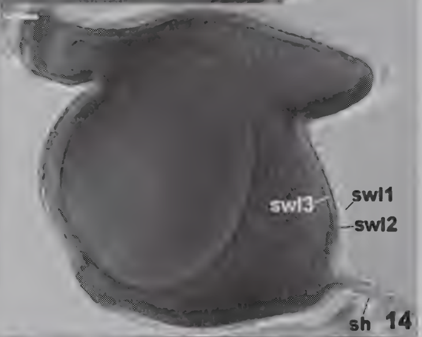
11


swl1
swl2
swl3

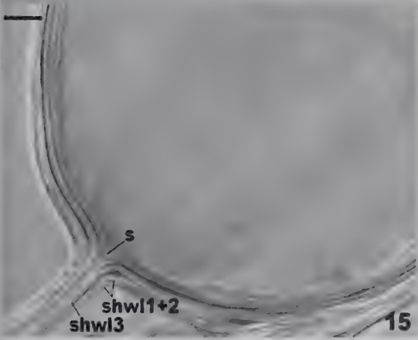
12


swl3
swl2
swl1
sl

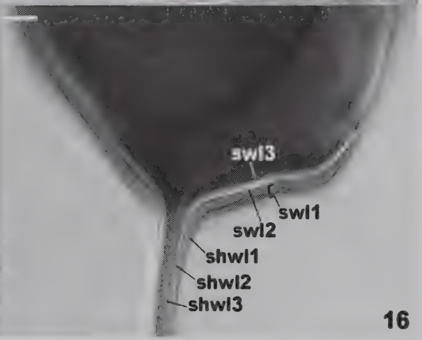
13


swl3
swl1
swl2
sh

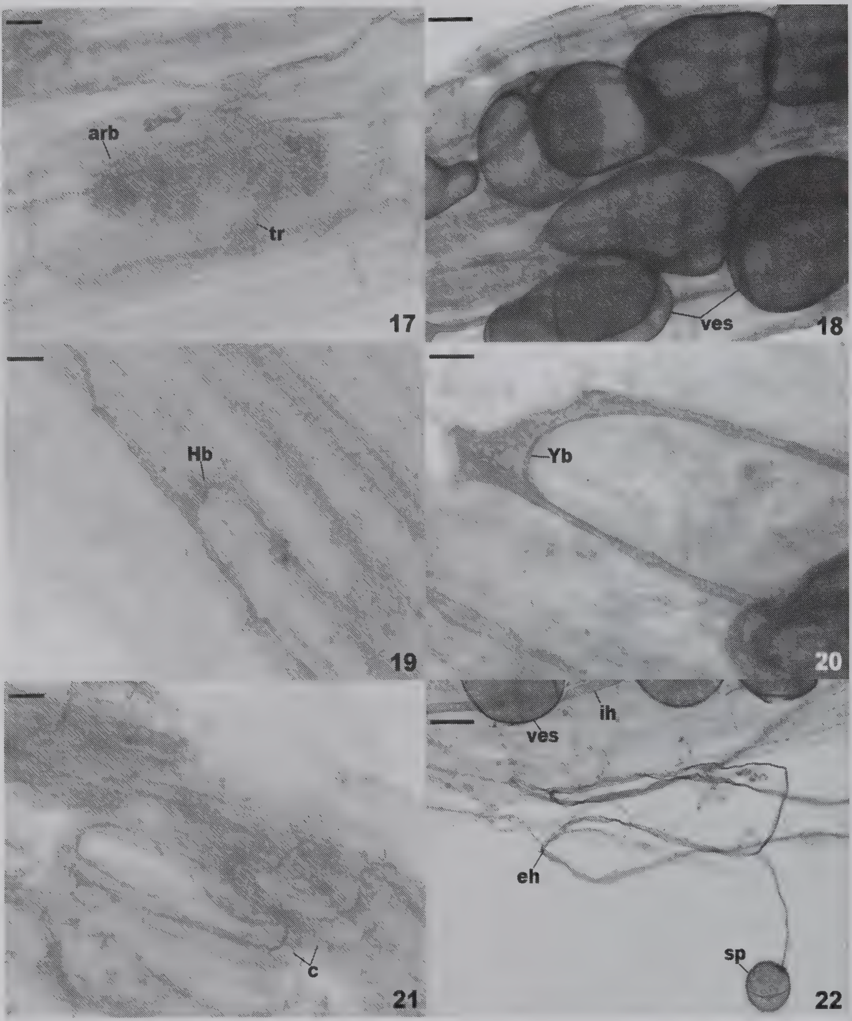
14


s
shwl1+2
shwl3

15


swl3
swl1
swl2
shwl1
shwl2
shwl3

16



Figs 17–22. Mycorrhizae of *Glomus irregulare* in roots of *Plantago lanceolata* stained in 0.1% trypan blue. (bright field). **17.** Arbuscule (arb) with trunk (tr). **18.** Vesicles (ves). **19.** H-shaped branch (Hb). **20.** Y-shaped branch (Yb). **21.** Coils (c). **22.** Vesicles (ves), straight intraradical hypha (ih), extraradical hyphae (eh), and young spore (sp).

Bars: Figs 17, 19–21 =10 µm; Figs 1, 18, 22=50 µm.

spores of *G. aurantium* Błaszk. et al. and an undescribed *Glomus* sp. were also found. Apart from *G. irregulare*, the arbuscular fungi sporulating in Majorca's cultures also were *G. aurantium*, *G. constrictum*, *Pacispora scintillans* (S.L. Rose & Trappe) Sieverd. & Oehl, and *S. calospora (*T.H. Nicolson& Gerd.) C. Walker

& F.E. Sanders. In the culture with the soil of the Giftung Island, spores of *G. drummondii* were still found.

The soil chemical properties of the dunes adjacent to Świnoujście ranged: pH, 3.8–6.7; NO_3 (mg L^{-1}), 20–72; P, 5–12; K, 2–26; Mg, 10–41; Na, 4–23; Cl, 15–25; KCl, 0.1–0.6; organic C (%), 0.1–1.1 (Błaszkowski 1995).

Discussion

The unique properties of *Glomus irregulare* are (1) the frequent formation of irregular spores with deep wall depressions and apical cap-like swellings of their outermost wall layer 1 (Figs 2, 5, 6, 8, 13, 14), (2) the production of spores mainly in oblong aggregates containing spores arising either from the tip of or intercalary along dichotomously branched hyphae continuous with mycorrhizal extraradical hyphae (Fig. 2), and (3) the intense reactivity of the laminate innermost spore wall layer in Melzer's reagent (Figs 4, 7, 11–14, 16). This fungus is additionally distinguished by the tendency to form spores mainly inside roots of its host plant (Fig. 1).

Our molecular analyses (Fig. 23, see above) show *G. intraradices* as the fungus most closely related to *G. irregulare,* although the analyses did not prove conclusively their separateness. In this study, the *G. irregulare* and *G. intraradices* spores used in phylogenetic analyses and to compare their morphologies and biochemical properties came from single-species pot cultures derived from pot trap cultures containing rhizosphere soils and *A. arenaria* roots from the Bornholm maritime dunes. Thus, the morphological, biochemical, and molecular divergences did not result from the influence of heterogeneous environments. Morton & Benny (1990b) found that spore characteristics of *G. intraradices* clonal populations remained consistent, even though they originated from highly differing environments. Lloyd-Macgilp et al. (1996), who compared the genetic diversity of arbuscular mycorrhizal fungi between and within different continents, noted that diversity did not increase with increasing geographical distance. Hence, the differences in the mode of formation of spores, their organization in aggregates, and the phenotypic and biochemical properties of components of their spore wall markedly separating the two fungi (see below comparisons and Figs 1–22, 24–31) are rather innate and, thereby, sufficiently important to support *G. irregulare* as a new taxon.

Seven properties separate *G. irregulare* from *G. intraradices*. First, whereas the distinctive property of *G. irregulare* is the formation of aggregates with spores arising both terminally and intercalary (Figs 2–8), the *G. intraradices* aggregates contain only terminal spores (Fig. 24; Błaszkowski, pers. observ.). Moreover, the intercalary mode of spore formation in *G. irregulare* usually causes the aggregates to be oblong and compact (Figs 2, 5, 6) rather than globose to ovoid (or irregular and loose) as in *G. intraradices* (Fig. 24; Błaszkowski

2003, Morton 2002). Second, the darkest *G. irregulare* spores [pale yellow (3A3); Figs 2, 5, 6, 8, 9, 10, and 15] are much lighter-coloured than the darkest *G. intraradices* spores [yellow brown to grey brown: Morton 2002, Schenck & Smith 1982; greyish yellow (2B5): Błaszkowski 2003], which still frequently have a greenish tint (Fig. 24; Błaszkowski 2003, Morton 2002, Schenck & Smith 1982; vs. no such a tint in *G. irregulare* spores). Third, most *G. irregulare* spores are irregular in shape and have distinctive wall depressions and apical cap-like swellings (Figs 1–3, 5, 6, 8, 13, 14). In contrast, almost all *G. intraradices* spores are globose to subglobose, and their wall has neither depressions nor swelling at the spore apex (Figs 24–31). Fourth, the two outer wall layers of *G. irregulare* spores are semi-permanent and usually intact or only slightly deteriorated in mature specimens (Figs 4, 9, 10, 11–14, 16), whereas those of *G. intraradices* are short-lived and frequently highly decomposed or completely sloughed at maturity (Figs 30, 31). The mucilaginous nature of the outermost wall layer of *G. intraradices* spores roughens their surface (Figs 26, 27, 29, 30). In contrast, the *G. irregulare* spore surface usually is smooth (Figs 4, 6, 8–16). Fifth, the laminate layer of *G. irregulare* spores consists of generally inseparable, thin (ca. 0.5 μm thick) laminae (Figs 4–14, 16), while the *G. intraradices* laminate spore layer comprises frequently separating, 0.5–1 μm thick, sublayers (Figs 26, 28, 31; Błaszkowski 2003, Morton 2002, Schenck & Smith 1982). The laminate layer also is much thinner (1.5–4.4 μm) in *G. irregulare* than in *G. intraradices* (3.2–12.0 μm). Sixth, the staining spore wall layer of *G. irregulare* in Melzer's reagent is only the laminate innermost layer (Figs 4, 7, 11–14, 16), whereas the reactive wall layer of *G. intraradices* spores in Melzer's is the mucilaginous outermost one (Figs 26–30; Błaszkowski 2003, Stürmer & Morton 1997). Finally, *G. irregulare* distinctively tends to hide its spores inside roots (Fig. 1) and only rarely produces extraradical spores, especially in field conditions. For example, ca. 160 field-collected mixtures of rhizosphere soils and roots of plants colonizing the Bornholm maritime dunes did not contain *G. irregulare* spores, but they occurred in over 80% of pot trap cultures of these mixtures after greenhouse cultivation (Błaszkowski, pers. observ.). Moreover, even in both trap and single-species cultures, *G. irregulare* did not begin to form extraradical spores until the third or the fourth cultivation cycle, although its numerous intraradical spores were still frequently visible in early control

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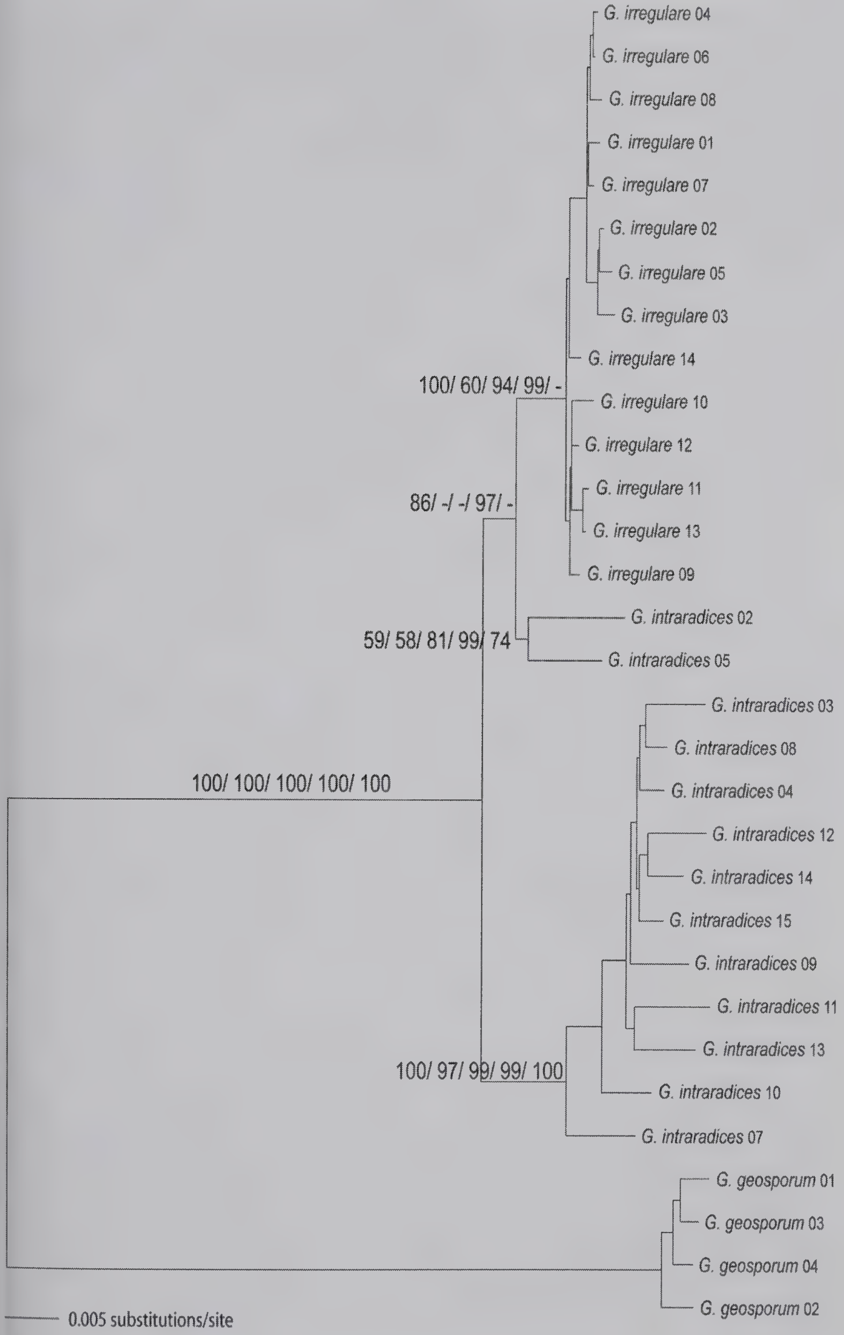
Fig. 23. BIONJ tree based on an alignment of nuclear SSU and ITS rDNA sequences obtained from *Glomus irregulare* and *Glomus intraradices* spores. A total of 2050 alignment positions were used for tree construction. The tree was rooted with *Glomus geosporum*. Branch support values (only values exceeding 50% are given) on branches refer to BIONJ bootstrap, BIONJ bootstrap (using GTR+I+G distances), Phyml bootstrap, maximum parsimony bootstrap, and posterior probabilities as estimated by Bayesian MCMC (GTR+I+G model of DNA substitution), respectively. All sequences were obtained in this study.


G. irregulare 04
G. irregulare 06
G. irregulare 08
G. irregulare 01
G. irregulare 07
G. irregulare 02
G. irregulare 05
G. irregulare 03
G. irregulare 14
100/ 60/ 94/ 99/ -
G. irregulare 10
G. irregulare 12
86/ -/ -/ 97/ -
G. irregulare 11
G. irregulare 13
G. irregulare 09
G. intraradices 02
59/ 58/ 81/ 99/ 74
G. intraradices 05
G. intraradices 03
G. intraradices 08
G. intraradices 04
100/ 100/ 100/ 100/ 100
G. intraradices 12
G. intraradices 14
G. intraradices 15
G. intraradices 09
G. intraradices 11
G. intraradices 13
100/ 97/ 99/ 99/ 100
G. intraradices 10
G. intraradices 07
G. geosporum 01
G. geosporum 03
G. geosporum 04
G. geosporum 02
0.005 substitutions/site

harvests of the first cycle cultures. In contrast, *G. intraradices* usually sporulated in the field and always formed numerous both intra- and extraradical spores during the first cultivation cycle in single- and multi-species cultures (Fig. 24; Błaszkowski, pers. observ.).

Another species of arbuscular mycorrhizal fungi of the genus *Glomus* morphologically resembling *G. irregulare* is *G. aggregatum*. This fungus also produces spores both in aggregates within roots and the soil and singly in the soil (Błaszkowski 1991, 2003; Koske 1985, Schenck & Smith 1982). Moreover, its spores are similar in size, somewhat in shape, and in having a 3-layered wall with two sloughing, hyaline outer layers and a laminate, yellow-coloured innermost layer. Although *G. aggregatum* frequently forms irregular spores, they have neither deep depressions nor apical cap-like swellings that characterize *G. irregulare* spores. Spores of *G. irregulare* with depressions also occur inside roots, suggesting that depressions are a genetically conserved character of this fungus rather than influenced by external conditions during spore development, e.g., caused by lack of space for neighbouring spores.

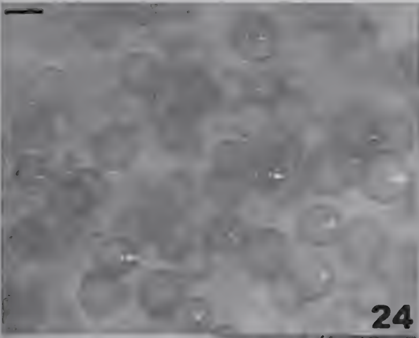
Apart from forming spores in aggregates and singly in the soil, *G. aggregatum* also produces new spores by internal proliferation within their parent spores (Błaszkowski 2003, Koske 1985), a phenomenon not found in *G. irregulare*. Additionally, *G. irregulare* spores are much lighter-coloured [hyaline to pale yellow (3A3)] than those of *G. aggregatum* [pale yellow to orange brown: Koske 1985; pastel yellow (2A4) to yellowish brown (5D8): Błaszkowski 2003].

The results of our phylogenetic analysis presented in Fig. 23 and analysis of two datasets based on SSU fragment and 5.8S together with the highly variable ITS2 region including related sequences available from GenBank also indicated that *G. irregulare* is closely related to the *G. intraradices* species complex (data not shown). Our data also showed that two *G. intraradices* sequences formed a separate subgroup associated with those of *G. irregulare*. This incomplete agreement between the evident differences in morphological properties of spores of *G. irregulare* and *G. intraradices* and the results of our phylogenetic analyses might be due to the highly conserved molecular markers used in this study. Hence, we suggest the use of additional or other genetic markers in further studies to explain the inconsistency revealed here.

Figs 24–31. Spores of *Glomus intraradices*. **24.** Loose aggregate of intact spores. (bright field) **25.** Intraradical spores. **26–28.** Spore wall layers 1–3 (swl1-3). **29.** Spore wall layers 1–3 (swl1-3) continuous with subtending hyphal wall layers 1–3 (shwl1-3). **30.** Spore wall layers 1–3 (swl1-3); note the highly deteriorated swl1. **31.** Spore wall layers 2 and 3 (swl2 and 3); layer 1 is completely sloughed in this spore.

(Fig. 24 bright field, spores in lactic acid. Figs. 25–31 DIC, spores mounted in PVLG+Melzer's reagent Fig. 31, spores mounted in PVLG)

Bars: Figs 26–31=10 μm; Fig. 25=50 μm; Fig. 24=100 μm.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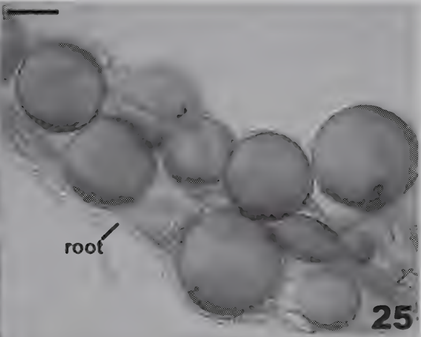
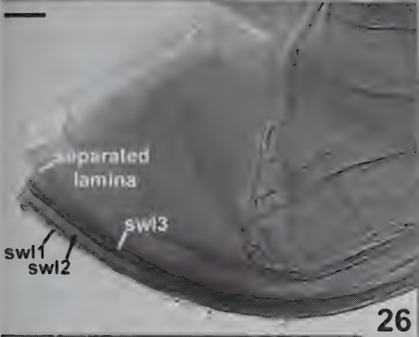
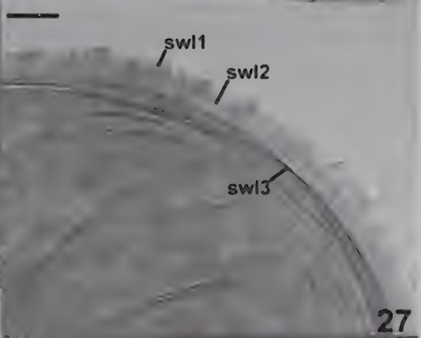
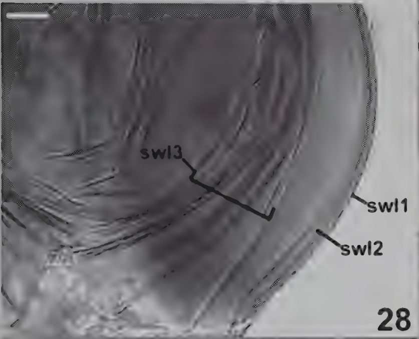
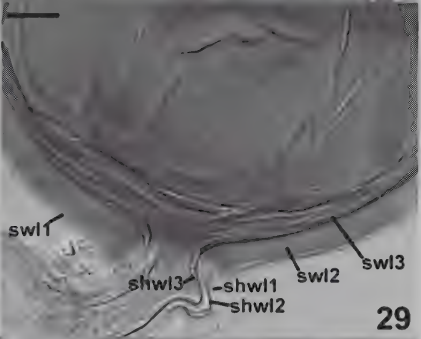
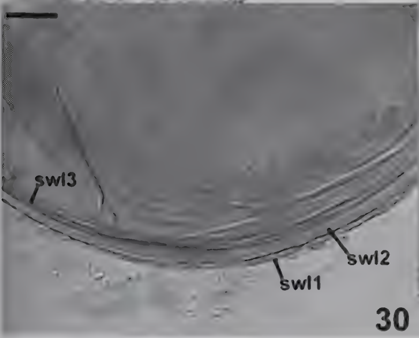

root
25

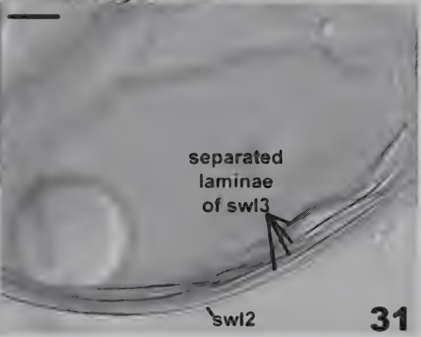

separated lamina
swl3
swl1
swl2
26


swl1
swl2
swl3
27


swl3
swl1
swl2
28


swl1
swl3
swl2
shwl3
shwl1
shwl2
29


swl3
swl2
swl1
30


separated laminae of swl3
swl2
31

As concluded above, *G. irregulare* is most closely related in molecular phylogenetic analyses to *G. intraradices*, a member of the subclade *Glomus* group Ab, also comprising *G. clarum* T.H. Nicolson& N.C. Schenck, *G. coremioides* (Berk. & Broome) D. Redecker & J.B. Morton, *G. fasciculatum*, *G. manihotis* R.H. Howeler et al., *G. proliferum* Dalpé & Declerck, *G. sinuosum* (Gerd. & B.K. Bakshi) R.T. Almeida & N.C. Schenck, and *G. vesiculiferum* (Thaxt.) Gerd. & Trappe (Schwarzott et al. 2001). Morphologically, however, *G. irregulare* more or less resembles only *G. fasciculatum*, *G. proliferum*, and *G. vesiculiferum*, fungi also producing spores in conglomerations.

In contrast to the primarily intercalary formation of irregular spores in *G. irregulare*, *G. fasciculatum* spores always arise terminally and are globose to subglobose (Błaszkowski 2003, Walker & Koske 1987). Moreover, the only spore wall component shared by the two species is their laminate layer. However, the laminate layer is the innermost structure of the *G. irregulare* spore wall, whereas in *G. fasciculatum* the laminae occur in the middle of the 3-layered spore wall. In the latter species, the two other spore wall layers are a permanent outermost layer and a flexible innermost one, whereas the laminate layer does not differentiate at all in *G. irregulare*.

Although *G. irregulare* and *G. proliferum* form intercalary and terminal spores in the soil and roots, *G. proliferum* spores are usually globose to subglobose (vs. mainly ovoid to irregular in the former fungus), markedly smaller [(22–)40–66(–76) μm diam vs. (70–)83(–100) μm diam when globose], and have different spore wall phenotypic and biochemical properties (Błaszkowski 2003, Declerck et al. 2000). Phenotypically, these fungi link only their laminate innermost layer. However, this layer stains in Melzer's reagent in *G. irregulare*, and is nonreactive in *G. proliferum*.

The globose spores of *G. irregulare* and *G. vesiculiferum* are similar in colour and size, but *G. vesiculiferum* is unique in that its spores are grouped in sporocarps with a peridium-like layer consisting of thin-walled, ellipsoid to broadly clavate vesicles (Gerdemann & Trappe 1974). In contrast, *G. irregulare* spores occur in loose aggregates with no peridium and/or singly in the soil. Additionally, the *G. vesiculiferum* spore wall is 2-layered, not 3-layered as in *G. irregulare*. Unfortunately, the reactivity of *G. vesiculiferum* spores in Melzer's reagent is unknown.

Although *G. irregulare* was identified in only 143 of ca. 5000 mixtures of rhizosphere soils and roots examined by the first author of this paper during the last 25 years (of which 133 mixtures came from Bornholm), the presence of this fungus in different regions of Europe, Africa and in Australia (Dr. C. Walker, Royal Botanic Garden Edinburgh; pers. comm.) suggests it is widely distributed in the world. The rare finding of *G. irregulare* probably results from the tendency to hide its spores inside roots and the exceptionally rare production of extraradical spores. For example, in the field soil samples collected in Świnoujście (Poland) and Veriko (Greece), in which extraradical spores were found, their abundance in 100 g dry soil was very low, i. e., 11 and 2, respectively.

Acknowledgements

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Calvatia sculpta, a striking puffball occurring on Brazilian sand dunes

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Abstract — This North American species was discovered for the first time in South America, growing on sand dunes associated with native tree roots. A description, comments, illustration of the basidiome and SEM-photo of the spores are given.

Key words — *Lycoperdaceae*, gasteromycetes, neotropics, taxonomy, chorology

Introduction

H. W. Harkness described *Lycoperdon sculptum* in 1885 from specimens collected in the Sierra Nevada Mountains in California, and in 1904 Lloyd transferred the species to the genus *Calvatia*. This North American species has a very restricted geographic distribution and is considered uncommon by some mycologists (Arora 1986). It is quite unique, owing to its basidiomata with surfaces covered by various pyramid-like structures. It can easily be confused with *Calbovista subsculpta* Morse ex M.T. Seidl, which exhibits felty warts and a root-like soil attachment. In some cases it can also be confused with immature specimens of *Amanita magniverrucata* Thiers & Ammirati. A classification in the *Calvatia* complex was proposed by Lange (1993).

Material and methods

Field expeditions were made in June 2007 in an Atlantic forest remnant in Parque Estadual das Dunas in Natal (05°46' S, 35° 12 W), Rio Grande do Norte state. The specimens examined are deposited in the Mycological Herbarium of the Botany, Ecology and Zoology Department in Natal, Brazil (UFRN).

Macroscopic characters were described based on observations of fresh and dried material. Free-hand sections of gleba and peridium were mounted in water, 3% (w/v) KOH, and 2% cotton blue lactophenol on glass slides and observed under a light microscope (LM). Forty randomly selected basidiospores were measured under the LM at 1000x magnification. Spores from the gleba were dusted onto specimen holders attached with double-sided carbon adhesive tape and then coated with up to 15 angstroms of gold-palladium on an Ion Sputter Coater to prepare for scanning electron microscopy (SEM). Colors were determined according to Kornerup & Wanscher (1978).

Results

Calvatia sculpta (Harkn.) Lloyd, Myc. Writ. 1: 203. 1904. FIGS. 1–2

Basionym: *Lycoperdon sculptum* Harkn., Calif. Acad. Sci. Bull. 1(3): 160. 1885.

Basidiomata epigeous, subglobose, 7–9 cm broad, white. Exoperidium thick, rimose and cracking into pyramidal warts horizontally grooved by parallel lines (Fig 1). Endoperidium thin, fragile. Sterile base present occupying one third of the basidioma, chambered, yellowish white (4A2), lacking a rooted base. Gleba pulverulent, pale yellowish (4A3). Capillitial threads 4-9 µm broad, branched, septate, pitted, light brown. Basidiospores globose, 3.5–4 µm broad, minutely verrucose under SEM, pedicel short (Fig. 2), light brown.

KNOWN DISTRIBUTION: United States of America (Harkness 1885, Coker & Couch 1928, Zeller 1964, Arora 1986)

MATERIAL EXAMINED: BRAZIL, Rio Grande do Norte, Natal, Parque Estadual das Dunas, Natal, on sandy soil, Baseia, 13-VI-2007 (UFRN–fungos 612).

NOTES: Basidiospore sizes vary greatly in *C. sculpta*, with spores ranging in size from 3.5–4.0 µm to 7.2–9.5 µm diam in specimens collected in the USA (Kreisel, pers. comm.). The material collected in Brazil has spores in the lowest margin (3.5–4.0 µm).

Discussion

Calvatia sculpta is a North American species that is normally associated with conifers in the inland mountains of California, Oregon, Washington, and Idaho (Zeller & Smith 1964). It appears restricted in range and has yet to be reported from the Pacific coast (Arora 1986). The discovery of this species in a dune biome in the Northeast of Brazil associated with native tree roots (*Eugenia brasiliensis* Lam., *Myrtaceae*) challenges hypotheses by Mueller et al. (2007) regarding its ecology and geographic distribution. One hypothesis proposes that *C. sculpta* is an ancient species that already existed before the Americas drifted apart. A second suggests that a dispersal agent (likely an

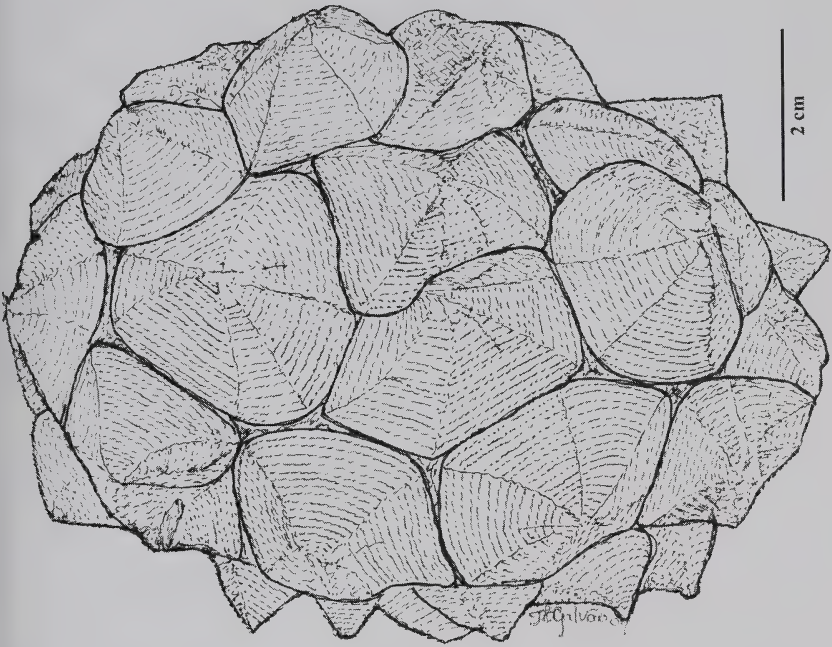

FIG. 1. *Calvatia sculpta*, general view of the basidioma.

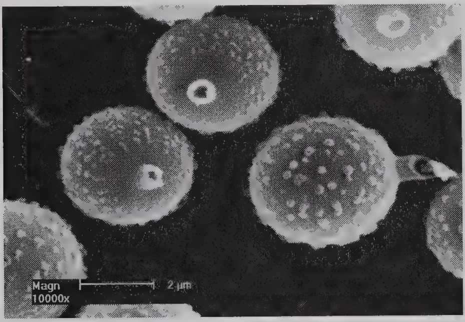

FIG. 2. *Calvatia sculpta*. details of the basidiospores under SEM.

anthropological action) introduced this organism into new biomes where it adapted by associating itself with other plant species. A third hypothesis is that there are at least two distinct species that share similar morphological features and correspond to cryptic species. Molecular studies are needed to test the hypotheses and help determine the true relationships between the North American and South American *C. sculpta* populations.

The systematics of *Calvatia* have been modified during the past decade based on morphological characters. In 1992, Kreisel proposed sect. *Sculpta* to accommodate *C. sculpta*; two years later the same author (Kreisel 1994) combined sections *Cretacea* and *Sculpta* based mainly on characters published by Lange (1990, 1993, 1994), thus placing *C. sculpta* close to *C. arctica* Ferd. & Winge.

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Selected species of *Mucorales* from soil contaminated with toxic metals in São Paulo State, Brazil

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Abstract — Eleven taxa of *Mucorales* were isolated from soil-plates made with malt agar amended with 0, 100, 200, 500 or 1,000 mg/L of $Pb(NO_3)_2$ or $Zn(NO_3)_2$ and soil collected in an area contaminated with chemicals. The taxa isolated (*Mucor bainieri, M. circinelloides* f. *circinelloides, M. circinelloides* f. *lusitanicus, M. circinelloides* f. *janssenii, M. hiemalis* f. *hiemalis, M. hiemalis* f. *luteus, M. racemosus* f. *racemosus, Zygorhynchus moelleri, Absidia cylindrospora* v. *cylindrospora, Rhizopus arrhizus* v. *arrhizus* and *Cunninghamella phaeospora* v. *phaeospora*) are described, discussed, and illustrated. This is a second world record for *Mucor bainieri,* previously isolated only once in India, and the first record this species from Brazil.

Key words — soil fungi, soil pollution, *Mucoromycotina*, zygomycete

Introduction

Most Brazilian studies on *Mucorales* (*Mucoromycotina*) have been carried out in the northeast, north and southeast regions of the Brazil. These fungi have been isolated from herbivore dung (Batista 1948, Alves et al. 2002, Santiago & Cavalcanti 2007, Santiago 2008, Santiago et al. 2008), as contaminants in other fungal cultures (Batista & Vital 1955) and corn flour (Ribeiro et al. 2003), from sugar cane and rice cultivated soils and other kinds of soils (Upadhyay 1967, 1969, 1970, 1973, Santos et al. 1989) in Pernambuco State, decaying flowers and soil (Dantas 1953ab) and copper-mining soils (Santiago & Souza-Motta 2006) in Bahia State and soil in the States of Maranhão (Lira 1971) and Pará (Pfenning 1993).

In southeast, São Paulo State, another sequence of studies was performed on *Mucorales* from soil (Trufem 1978, Trufem 1981a–c, Antunes et al. 1993, Santos et al. 1998, Ruegger et al. 2002, Viriato 2003, Tauk-Tornisielo et al. 2005), herbivore dung (Trufem 1984, Trufem & Viriato 1985, Viriato & Trufem 1985a,b, Viriato 2003), water, soil and leaves (Schoenlein-Crusius & Milanez 1989, 1997, Wellbaum et al. 1999), soil polluted with bird dung (Schoenlein-Crusius et al. 1996), air (Schoenlein-Crusius et al. 2001), and soil and leaves from areas damaged by industrial pollution (Schoenlein-Crusius et al. 2006).

Efforts have been made to evaluate the state of knowledge of Brazilian macro- and microfungi, including *Mucorales,* from Cerrado reserves (Brazilian Savanna) in São Paulo State (Milanez et al. 1997), Atlantic Rain Forest reserves in Pernambuco State (Maia et al. 2006), areas of São Paulo State, of the northeast and its semi-arid regions (Trufem 1999, Trufem et al. 2006), microfungi (including *Mucorales*) from several regions and biomes (Pfenning 1997) and *Mucorales* of medical importance (Lacaz et al. 1998).

Herein we report on the distribution of additional Brazilian *Mucorales.*

Material and methods

Soil samples were collected up to 10 cm in depth at five sites in Santa Gertrudes Municipality, São Paulo State, Brazil, and each sample was a composite of three sub-samples collected in adjacent points (de Souza 2006). Four of the sites were located in an interdicted area at Fazenda Itaqui drainage basin near Santa Gertrudes glazed ceramics industrial complex and km 168 of Washington Luiz highway, where the industries discharged ceramic wastes containing toxic metals (i.e. Pb and Zn) and other chemicals that has contaminated the soil, groundwater and surface water (Bonacin Silva 2001). The use this area is banned by the environmental authorities until conclusion of actions and studies for its recovery. The fifth site was in the urban area of Santa Gertrudes (control site). Soil suspensions (10% w/v) were prepared using distilled sterile water transferred to 250 mL Erlenmeyer flasks, which were shaken 1.5 h at 70 rpm. In order to prepare soil-plates (Warcup 1950), 1 mL of the soil suspension was spread over the surface of a Petri dish containing MA (malt agar 2% w/v) previously amended with 0 (control), or 100, 200, 500 or 1,000 mg/L of $Pb(NO_3)_2$ or $Zn(NO_3)_2.6H_2O$ (based in Arnebrant et al. 1987). The assays were carried out in triplicate and the Petri dishes incubated 7 days at 20–23 °C. The colonies were transferred to PDA (potato dextrose agar) and incubated 7 days at 20–23 °C, then transferred to SMA (synthetic *Mucor* agar, Hesseltine 1954) and incubated in the dark 5–7 days at 25 °C, and when necessary at 20, 30, 37, 40 or 45 °C.

Slides were prepared with distilled water plus glycerol (2% v/v) or PVLG resin (Morton et al. 1993) at 50% (w/v). Twenty measurements were made for each fungal structure. The identifications were performed in accordance with the literature on *Absidia* (Hesseltine & Ellis 1964, Schipper 1990), *Cunninghamella* (Baijal & Mehrotra 1980, Lunn & Shipton 1983, Zheng & Chen 2001), *Mucor* (Benjamin & Mehrotra 1963, Schipper 1973, 1976), *Rhizopus* (Schipper 1984) and *Zygorhynchus* (Hesseltine et al. 1959, Schipper 1986). The cultures were preserved by immersion in sterile distilled water, lyophilized, numbered, and stored in the fungi culture collection of the Seção de Micologia e Liquenologia, Instituto de Botânica, in São Paulo City, São Paulo State, Brazil.

Results and discussion

Mucor bainieri B.S. Mehrotra & Baijal, Aliso 5: 237. 1963. PLATE 1

SPECIMEN EXAMINED: Brazil, São Paulo State, Santa Gertrudes, Fazenda Itaqui drainage basin, contaminated area near ceramic tile industries, 22°27'46"S 47°32'29"W, soil under grass, *J.I. de Souza & N.C. Schoenlein,* 30.VI.2003, No. *2033.*

Colonies 15–30 days old on SMA at 20 and 25 °C, producing a strong baker's yeast odor, obverse with thin mycelium, pale beige dotted in chestnut, or whitish with or without a yellowish cream margin, reverse yellowish cream, pale beige to orange beige, 71 × 68 mm in size, up to 7 mm high; sporangiophores sympodially branched, 57–1,560 µm long, 3.2–11.7 µm in diameter at base and 2.7–9.2 µm in diameter at apex; sporangia globose, slightly applanate, reddish amber to chestnut, sporangial wall deliquescent, 24–61 × 25–67 µm; columellae ellipsoidal, obovoid, pyriform, some globose, hyaline green to slightly greyish, collars present or absent, 11.6–40 × 13.2–45 µm; sporangiospores ellipsoidal, flattened at one side, hyaline green, 4.2–9.7 × 2.2–5 µm; azygophores branched or unbranched, sometimes on the same branch with sporangiophores, 5–12.5 µm in diameter; azygosporangia applanate, reddish amber to dark brown, some moss green (young), on azygophore apices, laterally located on some aerial or submerged hyphae, present in single-spore cultures, 26–62 × 28–75 µm, spines isolated or on stellar warts (starfish-like) up to 5 µm high; azygospores from azygosporangia not observed; chlamydospores isolated, catenate, apical or intercalate, hyaline to green, containing olive green to orange droplets, 7.2–26 × 8–16.4 µm; submerged mycelium containing olive green to orange droplets.

NOTES. Isolated on MA with 200 mg of $Pb(NO_3)_2$. After 5 days on SMA at 30 °C both normal growth and sporulation; after 5 days at 37 °C no growth but the culture grew when placed again at 25 °C. This rare species of *Mucor* was initially recorded from forest soil in Uttar Pradesh, India (Benjamin & Mehrotra 1963). The strain No. *2033,* which corresponds to the first record of *M. bainieri* from Brazil, constitutes only the second world record. Schipper (1976) supplied another description of the original strain (CBS 293.63) showing results of influence of light, media and inter-specific mating.

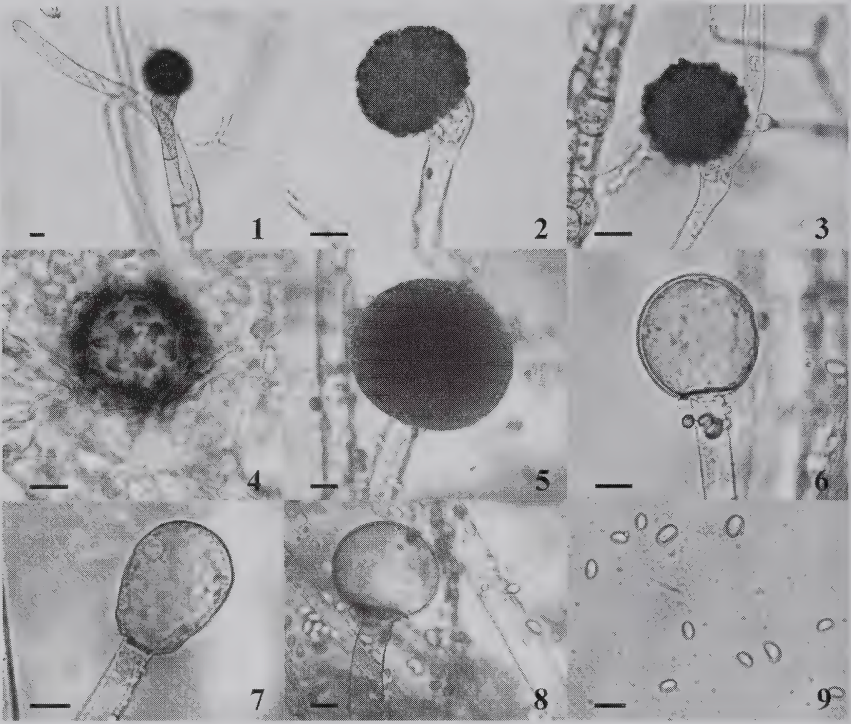

PLATE 1. *Mucor bainieri.* FIG. 1. Branched azygophore with terminal azygosporangium. FIGS. 2, 3. Azygosporangia. FIG. 4. Azygosporangium with stellar warts, in the submerged mycelium. FIG. 5. Sporangium. FIGS. 6–8. Columellae. FIG. 9. Sporangiospores. Bars = 10 µm.

Mucor circinelloides Tiegh., Annls. Sci. Nat. Bot., Sér. 6, 1: 94. 1875.
f. ***circinelloides*** PLATE 2 (FIGS. 1–5)

SPECIMEN EXAMINED: Brazil, São Paulo State, Santa Gertrudes, urban area, 22°27'12"S 47°32'39"W, soil from a public garden, *J.I. de Souza & N.C. Schoenlein,* 30.VI.2003, No. *2034.*

Colonies 5 days old on SMA at 25 °C, obverse beige dotted with chestnut, reverse greyish beige, pale orange at inoculum region, 90 mm in diameter, up to 6 mm high; sporangiophores sympodially branched, curved to almost circinate the short or straight the long, 22.5–1,010 µm long, 6.3–16.3 µm in diameter at base and 5–12.5 µm in diameter at apex; sporangia globose, slightly applanate, greenish chestnut to greenish golden yellow, sporangial wall deliquescent or persistent, 28–53 × 28–58 µm; columellae ellipsoidal, obovoid, or globose slightly applanate, mostly with collars, hyaline to brownish, 10.5–43 × 11.5–44 µm; sporangiospores globose, ovoid or ellipsoidal, smooth with homogeneous contents, olive green to brownish, 4.3–12.3 × 3.3–8.8 µm; chlamydospores apical, intercalate or catenate, thick walled, granular, with olive green to golden yellow contents, 18–41 × 13–32 µm; submerged mycelium three times as wide as the aerial hyphae and replete with olive green contents; zygosporangia not observed.

Notes. Isolated on MA with 100 mg of $Pb(NO_3)_2$. After 7 days on SMA at 37 °C normal growth and reduced sporulation; after 7 days at 40 °C, no growth. The form *circinelloides* was isolated from soil (Schoenlein-Crusius et al. 1996, 2006) and herbivore dung (Alves et al. 2002, Santiago 2008); *M. circinelloides* was isolated from soil (Trufem 1978, Antunes et al. 1993, Ruegger et al. 2002), herbivore dung (Trufem & Viriato 1985) and leaves (Schoenlein-Crusius & Milanez 1989).

Mucor circinelloides f. ***lusitanicus*** (Bruderl.) Schipper,
Stud. Mycol. 12: 9. 1976. Plate 2 (figs. 6–8)

Specimen examined: Brazil, São Paulo State, Santa Gertrudes, urban area, 22°27'12"S 47°32'39"W, soil from a public garden, *J.I. de Souza & N.C. Schoenlein*, 30.VI.2003, No. *2035*.

Colonies 6 days old on SMA at 25 °C, obverse powdery grey or greenish chestnut, with or without a whitish to beige margin, pale orange at the inoculum site, reverse pale beige, slightly grey, 78 mm in diameter, 2 mm high centrally and 1 mm high on the remainder of the colony; sporangiophores sympodially branched, short or long, slightly curved, 9.2–1,550 µm long, 4.5–17.5 µm in diameter at base and 3.5–12.5 µm in diameter at apex, sometimes forming a flaccid turf up to 5 mm high; sporangia globose, applanate, golden yellow, greenish chestnut to almost black, sporangial wall deliquescent or persistent, 29–78 × 30–85 µm; columellae globose, slightly applanate, with large basal membranes or smooth and without collars, hyaline to light grey, with or without scattered granular contents, 9.2–48 × 10.2–50 µm; sporangiospores ellipsoidal, ovoid, or less frequently kidney- or drop-shaped, with a granular appearance, olive green, slightly pale chestnut spotted, 3.2–10.2 × 2.7–5.7 µm; chlamydospores apical, thick walled, full of olive green contents, 10.2–31 × 9.2–25 µm; submerged mycelium with greenish golden yellow contents; zygosporangia not observed.

Notes. Isolated on MA with 200 mg of $Pb(NO_3)_2$. After 7 days on SMA at 37 °C reduced growth and no sporulation; after 7 days at 40 °C no growth, however, growth commenced again when the colonies were placed at 25 °C. This form of *M. circinelloides* was isolated from herbivore dung (Alves et al. 2002, Santiago 2008).

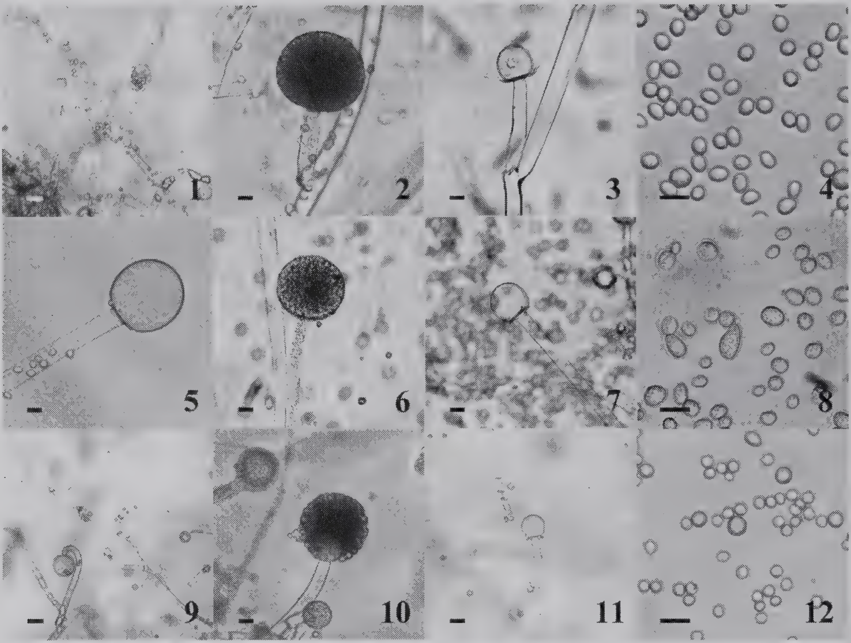

Plate 2. figs. 1–5. *Mucor circinelloides* f. *circinelloides:* 1. Short sympodial branches. 2. Sporangium on short sporangiophore. 3, 5. Columellae on short and long sporangiophores, respectively. 4. Sporangiospores. figs. 6–8. *M. circinelloides* f. *lusitanicus:* 6. Sporangium. 7. Columella. 8. Sporangiospores. figs. 9–12. *M. circinelloides* f. *janssenii*: 9. Short sympodial branches. 10. Sporangium on short sporangiophore. 11. Columella on long sporangiophore. 12. Sporangiospores. 1, 9 bars = 20 μm; 2–8, 10–12 bars = 10 μm.

Mucor circinelloides f. ***janssenii*** (Lendn.) Schipper, Stud. Mycol. 12: 13. 1976.
Plate 2 (figs. 9–12)

Specimen examined: Brazil, São Paulo State, Santa Gertrudes, urban area, 22°27'12"S 47°32'39"W, soil from a public garden, *J.I. de Souza & N.C. Schoenlein,* 18.III.2003, No. *2036.*

Colonies 5 days old on SMA at 25 °C, obverse powdery graphite grey with a pale beige to white margin, or powdery light orange grey without a margin, reverse pale beige, light grey or orange, 60 × 55 mm in size, up to 3 mm high; sporangiophores sympodially branched, slightly curved to circinate, with reduced apical width (short) or straight (long), septate or non-septate, 15–267(–821) μm long, 4.5–10 μm in diameter at base and 3–8.7 μm in diameter at apex; sporangia globose, slightly applanate, sporangial wall deliquescent, pale chestnut, dark chestnut to almost black, 16.5–56 × 18–57 μm; columellae globose, slightly applanate to ellipsoidal, collars present, with or without granular contents, hyaline to slightly grey, may be somewhat light greenish, 11.2–35 × 17–35 μm; sporangiospores globose, ovoid to almost spherical, smooth-walled, chestnut in mass, pale chestnut when individual, 3–6.7 × 2.2–6 μm; chlamydospores apical or intercalate, 9.7–23.2 × 8.2–16.5 μm; submerged mycelium with olive green contents, oidia present; zygosporangia not observed.

Notes. Isolated on MA with 100 mg of $Pb(NO_3)_2$. After 5 days on SMA at 20 and 30 °C growth and sporulation; after 5 days at 37 °C very poor growth and no sporulation but the culture grew when placed again at 25 °C. This form of *M. circinelloides* was isolated from soil (Schoenlein-Crusius et al. 1996, 2006), water, soil and leaves (Schoenlein-Crusius & Milanez 1997) and herbivore dung (Alves et al. 2002, Santiago 2008).

Mucor hiemalis Wehmer, Annls. Mycol. 1: 37. 1903.
f. ***hiemalis*** Plate 3 (figs. 1–4)

Specimens examined: Brazil, São Paulo State, Santa Gertrudes, urban area, 22°27'12"S 47°32'39"W, soil from a public garden; Fazenda Itaqui drainage basin, contaminated area near ceramic tile industries, 22°27'49"S 47°32'32"W, soil under grass, *J.I. de Souza & N.C. Schoenlein*, 28.V.2003, No. *2037–2039;* contaminated area near ceramic tile industries, 22°27'46"S 47°32'29"W, 22°27'58"S 47°32'22"W, soil under grass; *J.I. de Souza & N.C. Schoenlein*, 30.VI.2003, No. *2040*, No. *2041*.

Colonies 5–7 days old on SMA at 25 °C, obverse powdery, pale beige dotted in grey, or pale orange slightly white, reverse pale beige to pale orange with or without a deep orange (peach) coloration on inoculum site, 90 mm in diameter, 5–14 mm high; sporangiophores sympodially branched, straight to slightly curved, arising from the main branches, branches septate or non-septate, with or without granular orange contents, 34–2,650 μm long, 4–18.7 μm in diameter at base and 2.3–16.2 μm in diameter at apex; sporangia globose, slightly applanate, with sporangial wall highly deliquescent at 5 days, golden yellow, chestnut (amber) to greenish chestnut, 29–89 × 30–88 μm; columellae ellipsoidal, base may be truncate, pyriform, or globose, slightly applanate, collars present or absent, hyaline green to slightly grey, with or without granular contents, 7.2–56 × 7.5–46 μm; sporangiospores ellipsoidal, smooth, flattened at one side, with homogeneous or granular contents, pale green, with or without dark green droplets, 3–10.9 × 1.8–6.8 μm; chlamydospores apical, catenulate or intercalate, present or absent on the aerial mycelium, with or without olive green granular contents, 6.2–30 × 5–24.4 μm; submerged mycelium with olive green to greenish golden yellow contents, with or without rhizoid-like thin side branches, oidia present or absent; zygosporangia not observed.

Notes. Isolated on MA metal free, with 100 mg of $Pb(NO_3)_2$, and 200 mg of $Zn(NO_3)_2$. No strain grew after 7 days on SMA at 37 °C. The form *hiemalis* was isolated from soil (Schoenlein-Crusius et al. 1996, Santos et al. 1998, Ruegger et al. 2002, Tauk-Tornisielo et al. 2005), water, soil and leaves (Schoenlein-

Crusius & Milanez 1997), soil and leaves (Schoenlein-Crusius et al. 2006), and herbivore dung (Alves et al. 2002, Santiago 2008). *M. hiemalis* was isolated from soil (Trufem 1978, 1981a, Antunes et al. 1993), leaves (Schoenlein-Crusius & Milanez 1989, Wellbaum et al. 1999) and herbivore dung (Trufem 1984, Trufem & Viriato 1985).

Mucor hiemalis f. ***luteus*** (Linnem.) Schipper, Stud. Mycol. 4: 33. 1973.

PLATE 3 (FIGS. 5–8)

SPECIMENS EXAMINED: Brazil, São Paulo State, Santa Gertrudes, Fazenda Itaqui drainage basin, contaminated area near ceramic tile industries, 22°27'46"S 47°32'29"W, soil under grass, *J.I. de Souza & N.C. Schoenlein*, 28.V.2003, No. *2042–2046*, 30.VI.2003, No. *2047*.

Colonies 5–7 days old on SMA at 25 °C, sometimes with a strong baker's yeast odor, obverse pale beige to slightly orange to pale whitish orange, or containing a 50 mm central region up to 14 mm high of cotton-like mycelium greyish orange dotted in graphite grey, with a 8 mm high peripheral region with or without sectors of whitish dense mycelium, reverse orange, deep orange (peach) or yellow mango, 90 mm in diameter, up to 14 mm high; sporangiophores sympodially branched, septate or non-septate, sometimes curved, 25–5,750 µm long, 5.6–18.4 (–22.5) µm in diameter at base and 3.5–13.8 (–20) µm in diameter at apex; sporangia globose, slightly applanate, sporangial wall highly deliquescent, amber to greyish-greenish chestnut, 23.7–80 × 22.5–85 µm; columellae globose, slightly applanate, spherical or ellipsoidal, collars present or absent, with or without granular contents, hyaline green (minor) to slightly grey (major), 12.5–66 × 11.3–68 µm; sporangiospores narrow ellipsoidal, sometimes flattened at one side, some slightly curved, smooth-walled, with or without granular contents, pale green, 3.2–13.6 × 1.7–6.4 µm; chlamydospores catenulate, isolated, apical or intercalate, present or absent on aerial mycelium, 7.2–30 × 6.2–21.7 µm; submerged mycelium with olive green to golden yellow contents, sometimes with thin side branches, oidia absent; zygosporangia not observed.

NOTES. Isolated on MA with 100, 200 and 500 mg of $Zn(NO_3)_2$. No strain grew after 7 days on SMA at 37 °C; the strain No. *2044* showed reduced growth but no sporulation. This form of *M. hiemalis* was isolated from soil (Schoenlein-Crusius et al. 1996), air (Schoenlein-Crusius et al. 2001), soil and leaves (Schoenlein-Crusius et al. 2006) and herbivore dung (Alves et al. 2002).

Mucor racemosus Fresen., Beitr. Mykol. 1: 12. 1850.
f. ***racemosus***

PLATE 3 (FIGS. 9–12)

SPECIMEN EXAMINED: Brazil, São Paulo State, Santa Gertrudes, Fazenda Itaqui drainage basin, contaminated area near ceramic tile industries, 22°27'46"S 47°32'29"W, soil under grass, *J.I. de Souza & N.C. Schoenlein*, 30.VI.2003, No. *2048*.

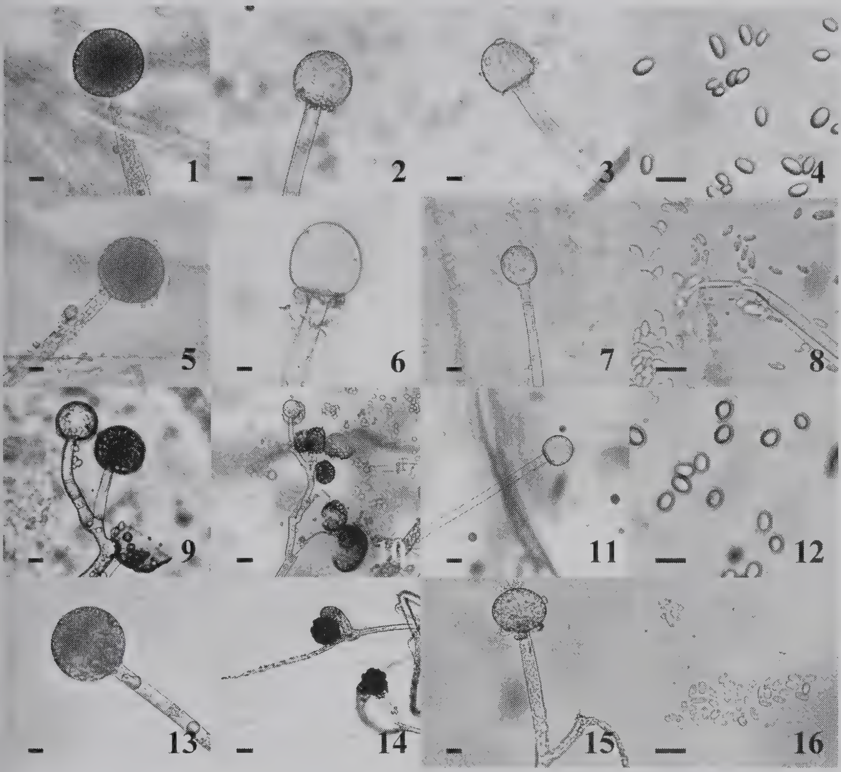

Plate 3. figs. 1–4. *Mucor hiemalis* f. *hiemalis:* 1. Sporangium. 2, 3. Columellae. 4. Sporangiospores. figs. 5–8. *M. hiemalis* f. *luteus:* 5. Sporangium. 6, 7. Columellae. 8. Sporangiospores. figs. 9–12. *M. racemosus* f. *racemosus:* 9, 10. Short sympodial branches. 11. Columella. 12. Sporangiospores. figs. 13–16. *Zygorhynchus moelleri:* 13. Sporangium. 14. Zygosporangia. 15. Columella. 16. Sporangiospores. 1–9, 11–13, 15, 16 bars = 10 µm; 10, 14 bars = 20 µm.

Colonies 5 days old on SMA at 25 °C, scarce mycelium, obverse pale greenish grey, powdery, dotted in graphite grey, some colonies with more dense and higher (7 mm) orange mycelium sectors, reverse grey slightly orange, 90 mm in diameter, 5 mm high; sporangiophores sympodially branched, short or long, septate or non-septate, 35–1,020 µm long, 7.5–13.8 µm in diameter at base and 6.3–11.3 µm in diameter at apex; sporangia globose, applanate, sporangial wall persistent or deliquescent from sporangia borned on short or long branches, respectively, pale chestnut (amber), dark chestnut to almost black, 28–90 × 30–95 µm; columellae ellipsoidal or globose, applanate, mostly with collars, hyaline green to slightly grey, 15–51 × 15–43 µm; sporangiospores wide ellipsoidal, pale green to slightly chestnut, 4.5–10.9 × 3.6–7.7 µm; chlamydospores isolated, catenulate or apical, 6.2–25 × 7.5–18.7 µm; submerged mycelium with olive green contents and terminating in oidia; zygosporangia not observed.

Notes. Isolated on MA with 100 mg of $Pb(NO_3)_2$. After 7 days on SMA at 37 °C no growth, but both growth and sporulation started again when the cultures were placed at 25 °C. The form *racemosus* was isolated from soil (Trufem 1978, Schoenlein-Crusius et al. 1996), herbivore dung (Viriato 2003) and soil and leaves (Schoenlein-Crusius et al. 2006). *M. racemosus* was isolated from soil (Upadhyay 1967, Santos et al. 1989, Antunes et al. 1993).

Zygorhynchus moelleri Vuill., Bull. Soc. Mycol. France 19: 117. 1903.
Plate 3 (figs. 13–16)

Specimen examined: Brazil, São Paulo State, Santa Gertrudes, Fazenda Itaqui drainage basin, contaminated area near ceramic tile industries, 22°27'49"S 47°32'32"W, soil under grass, *J.I. de Souza & N.C. Schoenlein*, 18.III.2003, No. *2051*.

Colonies 5 days old on SMA at 25 °C, obverse light greyish white, varying from pale grey sand to graphite grey in 25–30 days, highly dotted in black, dry mycelium, reverse pale greenish beige, 90 mm in diameter, 9 mm high, up to 12 mm high in 25–30 days; sporangiophores sympodially branched, slightly curved, some very short bearing almost sessile sporangia, 31–250 µm long, 3.7–12.5 µm in diameter at base and 2.5–12.5 µm in diameter at apex; sporangia globose, pale chestnut brilliant (amber), sporangial wall persistent, smooth, 15–48 × 15–46 µm; columellae applanate, greenish hyaline to slightly chestnut, 9–30 × 19.5–44 µm; sporangiospores ellipsoidal, some curved, to bean-shaped, pale green, mostly showing olive green droplets in the apices, 3.7–6.7(–11.2) × 2.2–3.7 µm; chlamydospores rare; submerged mycelium with olive green brilliant contents; zygosporangia very abundant, globose to slightly applanate, pale chestnut (amber) when young, dark chestnut to black when mature, 30–45 × 32–47 µm, with spines 5–7(–10) µm high; suspensors unequal, one thin, long, straight and other inflated and bending to the former; homothallic; azygosporangia not observed.

Notes. Isolated on MA with 100 mg of $Pb(NO_3)_2$. Brazilian isolates of *Z. moelleri* from soil were studied by Hesseltine et al. (1959). Other authors isolated it from soil (Trufem 1978, Antunes et al. 1993, Schoenlein-Crusius et al. 2006), leaves (Schoenlein-Crusius et al. 1990) and water, soil and leaves (Schoenlein-Crusius & Milanez 1997).

Absidia cylindrospora Hagem, Skr. Vidensk.-Selsk. Christiania, Kl. I, Math.-Natur. 1907(7): 45. 1908. var. ***cylindrospora***
Plate 4 (figs. 1–4)

Specimens examined: Brazil, São Paulo State, Santa Gertrudes, Fazenda Itaqui drainage basin, contaminated area near ceramic tile industries, 22°27'59"S 47°32'22"W, soil under

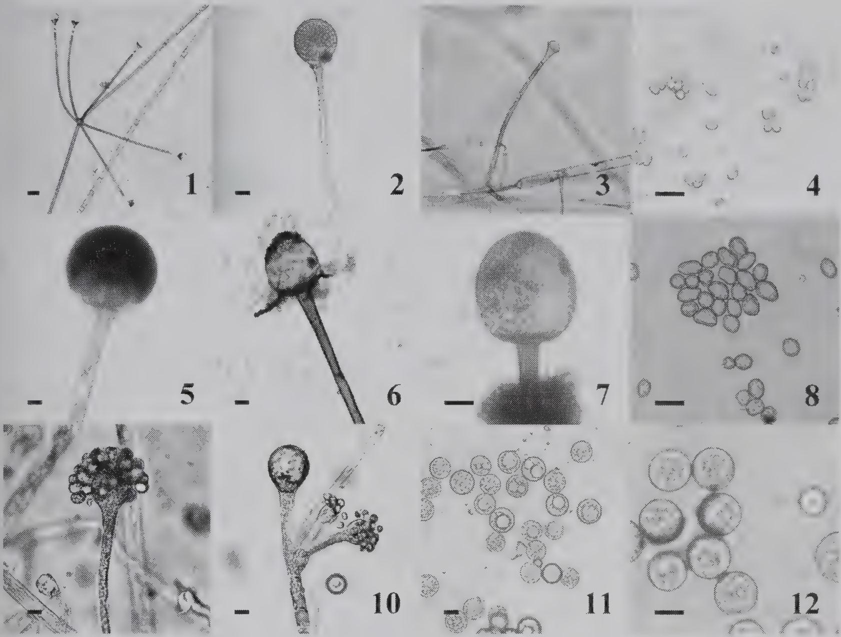

Plate 4. figs. 1–4. *Absidia cylindrospora* v. *cylindrospora:* 1. Verticil. 2. Sporangium. 3. Columella. 4. Sporangiospores. figs. 5–8. *Rhizopus arrhizus* v. *arrhizus:* 5. Sporangium. 6, 7. Columellae. 8. Sporangiospores. figs. 9–12. *Cunninghamella phaeospora* v. *phaeospora:* 9. Sporangiophore monopodially branched. 10. Terminal vesicle and lateral branches. 11, 12. Sporangiola unispored.
1, 3, 5–7 bars = 20 µm; 2, 4, 8, 9–12 bars = 10 µm.

grass, J.I. de Souza & N.C. Schoenlein, 18.III.2003, No. 2031; urban area, 22°27'12"S 47°32'39"W, soil from a public garden, J.I. de Souza & N.C. Schoenlein, 18.III.2003, No. 2030.

Colonies 5 days old on SMA at 25 °C, obverse greyish white, chestnut in 25–30 days, reverse wavy zonate, pale creamy beige, 76 mm in diameter and 15 mm high; sporangiophores pale chestnut, pale beige, or hyaline green when small, arising singly, in pairs or in verticils 3 or 4(–5), produced on stolons, 50–364 µm long, 2.5–8.2 µm in diameter at base and 2.2–5.5 µm in diameter at apex, septate; sporangia spherical at the apices, conical at the base, apophysate, smooth, pale olive green to chestnut, sporangial wall deliquescent, 12.5–30 × 13.8–33 µm; columellae rounded, with or without 1.2–6.2 µm thin erect projections sometimes inflated at the apex, sporangial membranes between the columella-apophysis region may persist, pale olive green to pale beige, 6.2–20 × 10–22.5 µm; sporangiospores cylindrical with round extremities, pale green, 3.5–5.7 × 2.2–3.2 µm; chlamydospores apical or isolated, scarce, 4.5–17.5 × 4.5–

10.5 µm; submerged mycelium containing olive green droplets; zygosporangia not observed.

NOTES. Isolated on MA with 100 mg of $Pb(NO_3)_2$, and 200 mg of $Zn(NO_3)_2$. After 5 days on SMA at 30 °C slightly decreased growth and normal sporulation; after 7 days at 37 °C no growth; after 5 days at 25 °C on malt extract agar pale brownish-greenish grey colonies were developed, indicating the variety *cylindrospora* (Schipper 1990). Brazilian isolates of the variety *cylindrospora* were obtained from Brazil nuts, soil (Hesseltine & Ellis 1964) and soil (Pfenning 1993). Isolates of *A. cylindrospora* were obtained from soil (Upadhyay 1970, Lira 1971, Trufem 1978, 1981b, Antunes et al. 1993, Schoenlein-Crusius et al. 1996, Santiago & Souza-Motta 2006), soil and leaves (Schoenlein-Crusius & Milanez 1997), soil and herbivore dung (Viriato 2003) and corn flour (Ribeiro et al. 2003).

Rhizopus arrhizus A. Fisch., Rabenh. Krypt.-Fl. Ed. 2, 1(4): 233. 1892.
var. ***arrhizus*** PLATE 4 (FIGS. 5–8)

= *Rhizopus oryzae* Went & Prins. Geerl., Verh. K. Nederl. Akad. Wet., 2 Sect. 4(2): 16. 1895.

SPECIMENS EXAMINED: Brazil, São Paulo State, Santa Gertrudes, Fazenda Itaqui drainage basin, contaminated area near ceramic tile industries, 22° 27' 46" S 47° 32' 29" W, soil under grass, *J.I. de Souza & N.C. Schoenlein*, 30.VI.2003, No. *2049*, No. *2050*.

Colonies 7 days old on SMA at 25 °C, obverse greyish white densely dotted with black sporangia, reverse greyish creamy white, sometimes yellowish, 90 mm in diameter, 15 mm high; sporangiophores arising from stolons connected to substrate by rhizoids, sometimes almost verticillate, arising from vesicle apices of wide hyphae, or on isolated dichotomous branches, chestnut to hyaline green near substrate, some entirely hyaline green, 370–1,600 µm long, 7.5–20 µm in diameter at base and 15–30 µm in diameter at apex; sporangia globose, apophysate, slightly olive green when young, grey to black when mature, sporangial wall persistent and smooth, 50–160 × 60–165 µm; columellae ellipsoidal with truncate base or globose, without collars or with great remaining sporangial membranes adhered to the base, pale chestnut to hyaline green, 27.5–120 × 37.5–120 µm; sporangiospores ellipsoidal/subglobose angular, thick walled, slightly striate, greenish to slightly chestnut when solitary, greenish grey when in mass, sometimes in pairs, 5.5–12 × 4–9 µm; chlamydospores absent; submerged mycelium with rhizoids; zygosporangia not observed.

NOTES. Isolated on MA with 200 mg of $Pb(NO_3)_2$. After 7 days on SMA at 45 °C poor growth and no sporulation; after 7 days at 37 °C slightly decreased growth and sporangia without free sporangiospores. *R. arrhizus* was isolated from soil (Trufem 1981b), water, soil and leaves (Schoenlein-Crusius & Milanez 1997) and herbivore dung (as *R. oryzae*, Santiago 2008).

Cunninghamella phaeospora Boedijn, Sydowia 12: 348. 1959 ['1958'].
var. ***phaeospora*** PLATE 4 (FIGS. 9–12)

SPECIMEN EXAMINED: Brazil, São Paulo State, Santa Gertrudes, urban area, 22°27'12"S 47°32'39"W, soil from a public garden, *J.I. de Souza & N.C. Schoenlein,* 18.III.2003, No. *2032.*

Colonies 5 days old on SMA at 25 °C, like moist cotton, obverse greyish white, to pale grey in 25–30 days, reverse wavy zonate, creamy white, to greyish creamy beige in 25–30 days, 84 × 61 mm in size and 16 mm high; aerial mycelium abundant, 6.2–22.5 µm in diameter; sporangiophores hyaline to olive green, septate or non-septate, monopodially branched (very long), with isolated dichotomous branches, lateral branches, or arising from stolons (minority), rarely pseudoverticillate, up to 90 µm long, 7.5–13.7 µm in diameter, sympodial branches absent; terminal vesicles hyaline to olive green, 17.5–46 µm in diameter at the wider part, lateral small vesicles on aerial mycelium up to 11.2 µm in diameter; pedicels up to 5 µm long; sporangiola unispored, almost spherical or globose, rarely lemon-shaped, hyaline green to olive green or pale chestnut, 12.5–18.8 × 12.2–18.2 µm, mostly spineless, or rarely with spines 1.8–3.6 µm long; chlamydospores absent; rhizoids sometimes finger-like; submerged mycelium with inflated regions sometimes with olive green drops, ending with thin hair-like irregular branches; zygosporangia not observed.

NOTES. Isolated on MA with 100 mg of $Zn(NO_3)_2$. After 5 days on SMA at 20 and 30 °C normal growth and sporulation; after 7 days at 37 and 45 °C no growth. The strain No. *2032* generally formed globose sporangiola (12.5–18.8 × 12.2–18.2 µm), which are relatively larger than the globose, lacrymoid and ovoid (6.6–16.0 µm) ones that has been observed (Baijal & Mehrotra 1980, Lunn & Shipton 1983, Zheng & Chen 2001). *C. phaeospora* was isolated from soil (Upadhyay 1970, Santos et al. 1998, Viriato 2003, Maia et al. 2006).

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Validation and typification of *Laetiporus montanus*

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Abstract — *Laetiporus montanus* (*Basidiomycota, Polyporales*) is an invalidly described taxon growing on conifers in Central European mountain areas. A molecular phylogenetic study of the species was performed to reveal its taxonomical position. The sequencing of ITS and LSU regions of ribosomal DNA revealed high proximity of the sequences of *L. montanus* to the North American species *L. huroniensis*. Nevertheless, DNA sequences of the two taxa are not identical and these species also differ in basidiospore dimensions. The ITS sequence of *L. montanus* is also identical to Japanese specimens named as *L. sulphureus* var. *miniatus*. However, the basionym of this taxon, *Polyporus miniatus*, was described from the tropics and its identity with temperate conifericolous specimens is improbable. Therefore, *Laetiporus montanus* sp. nov. is validated and described here.

Key words — *Basidiomycetes, Picea, Larix*, taxonomy, polyporoid clade

Introduction

Laetiporus sulphureus s.l. is a large, yellow to orange polypore, considered to be widely distributed from boreal to tropical zones. It grows on different broadleaved and coniferous hosts causing brown rot of wood, occasionally resulting in economical losses. As in many other fungal species, *Laetiporus sulphureus* s.l. is formed of a complex of several sibling species. North American studies revealed the presence of five species and one variety within the *L. sulphureus* complex (Burdsall & Banik 2001). In Central Europe a morphologically and ecologically distinguishable species, *Laetiporus montanus*, was described by Černý (1989). However, the name *Laetiporus montanus* Černý was published invalidly, because a Latin diagnosis and an indication of the type are lacking in the publication (Černý 1989). Nevertheless, the taxon seems to be a good species restricted to coniferous wood in mountain areas, differing from other Central European *Laetiporus* specimens by its larger basidiospores. The aim of our work is to confirm the taxonomic position of *L. montanus* according to sequences of ribosomal DNA.

Material and methods

To assure the taxonomic position of *Laetiporus montanus*, sequencing of the ITS and LSU regions of nuclear ribosomal DNA was carried out.

A representative specimen of *L. montanus*, collected in the locality mentioned in original publication (Černý 1989), deposited in BRNM (no. 706688), and the respective culture deposited in MUAF culture collection (Collection of Mendel University of Agriculture and Forestry in Brno, Department of Forest Protection and Wildlife management), isolate no. 856, were selected for the study. The specimen was sequenced together with a sample of *L. sulphureus* s.s., collected in the Czech Republic on *Sorbus aucuparia*, deposited in BRNM (specimen 706696).

DNA was isolated from fresh culture and from dried tissue of herbarium specimens using PowerSoil™ DNA Isolation Kit (Mo-Bio). The DNA was amplified with PCR, using the Mastercycler® ep thermocycler (Eppendorf). The PCR amplifications were performed according to Tomšovský et al. (2006).

Sequences were determined with an ABI PRISM 3100 Avant DNA sequencer (Applied Biosystems) at the Department of Animal Morphology, Physiology and Genetics, Faculty of Agriculture, Mendel University, Brno using the ABI PRISM BigDye terminator v1.1 cycle sequencing kit (Applied Biosystems). All samples were sequenced with the primers used in the PCR.

GenBank search of newly obtained ITS and LSU sequence of *L. montanus* using BLAST (Altschul et al. 1990) resulted in 99–100 % identity with those of the North American conifer-inhabiting species *Laetiporus conifericola* Burds. & Banik and *Laetiporus huroniensis* Burds. & Banik (GenBank Access. Nos. EU402523–24, EU402539–40, EU402569–78; Lindner & Banik 2008). In the case of *L. montanus* ITS sequences, 100 % identity with Japanese specimens of *L. sulphureus* var. *miniatus* (GenBank Accession Nos. AB308192-95; Ota & Hattori 2008) was revealed.

Newly obtained sequences were edited manually using BioEdit version 4.7.1. (Hall 1999), and selected *L. conifericola, L. huroniensis* and *L. sulphureus* var. *miniatus* sequences from the GenBank (GenBank Accession Nos. see at Fig. 1) were added to the dataset. The combined ITS and LSU alignment with introduced gaps consisted of 1183 characters including 1163 constant and 20 variable sites.

A neighbor-joining phylogenetic analysis was carried out using MEGA 4 (Tamura et al. 2007). The phylogram was constructed using the maximum composite likelihood model and the support for the topology of the dendrogram was estimated using 1000 bootstrap-replicates.

Results and discussion

The newly obtained *Laetiporus montanus* sequences of both gene regions show high similarity to the North American species *L. huroniensis*, while *L. conifericola* forms a sister clade (Fig. 1). However, there are some differences between the sequences of *L. montanus* and *L. huroniensis* (Tables 1, 2) and also their basidiospore dimensions differ. *L. montanus* has broadly ovoid basidiospores, (5.8) 6.0–8.0 (9.0) × (3.8) 4.0–5.5 µm (Černý 1989; own observations), while those of *L. huroniensis* are smaller (5.0–7.0 × 4.2–5.0 µm; according to Burdsall

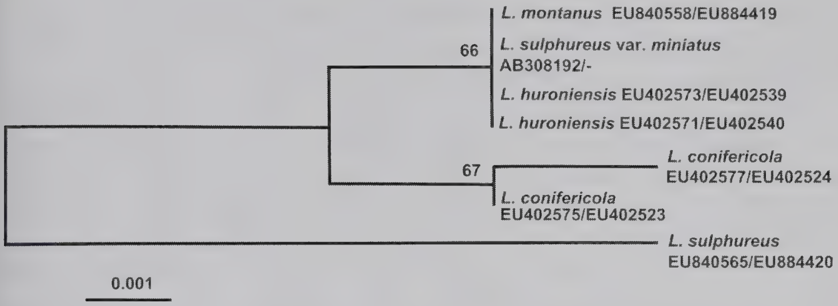
L. montanus EU840558/EU884419
66
L. sulphureus var. miniatus AB308192/-
L. huroniensis EU402573/EU402539
L. huroniensis EU402571/EU402540
67
L. conifericola EU402577/EU402524
L. conifericola EU402575/EU402523
L. sulphureus EU840565/EU884420
0.001

FIGURE 1. Phylogenetic tree of *Laetiporus montanus* and related taxa based on combined sequences of the ITS and LSU regions of nuclear ribosomal DNA region (the first GenBank accession number refers to the ITS sequence the second one to LSU sequence). The tree was constructed by a neighbor-joining analysis; bootstrap values are shown at the nodes. The bar indicates the number of substitutions per position.

TABLE 1. Comparison of nucleotide polymorphism of aligned conifericolous *Laetiporus* ITS sequences.

SPECIMEN	ITS POSITION NO.					
	1–5	15	96	413	507–513	517
L. montanus EU840558	ACGAA	C	T	G	TTCGGAC	A
L. sulphureus var. *miniatus* AB308192	ACGAA	C	T	G	TTCGGAC	A
L. huroniensis EU402573	ACGAA	C	T	G	- - - - - - -	A
L. huroniensis EU402571	ACGAA	C	T	G	- - - - - - -	A
L. conifericola EU402577	ACGAA	T	C	A	TTCGGAC	–
L. conifericola EU402575	ACGAA	T	C	A	TTCGGAC	–

TABLE 2. Comparison of nucleotide polymorphism of aligned conifericolous *Laetiporus* LSU sequences.

SPECIMEN	LSU POSITION NO.						
	1–7	175	491–492	541	558	567	589
L. montanus EU884419	GGATTCC	C	- -	C	T	C	–
L. huroniensis EU402539	GGATTCC	T	TA	C	G	C	G
L. huroniensis EU402540	GGATTCC	T	TA	C	G	C	G
L. conifericola EU402524	GGATTCC	T	- -	T	G	T	–
L. conifericola EU402523	GGATTCC	T	- -	T	G	T	–

& Banik 2001). Basidiospore dimensions of *L. conifericola* are almost identical to those of *L. montanus* (6.5–8.0 × 4.0–5.0 µm), but the two species differ in their DNA sequences more than *L. huroniensis* differs from *L. montanus*.

The ITS sequences of *L. montanus* and Japanese material of *L. sulphureus* var. *miniatus* are identical. In addition, colour of basidiocarp surface and pores, and substrate specificity of these two taxa are almost identical (Ota & Hattori 2008; Černý 1989). Unfortunately, Ota & Hattori's publication lacks basidiospore dimensions and LSU sequence data, which could be used to assure the identity of Central European *L. montanus* and these Japanese fungi. The name *L. sulphureus* var. *miniatus* (Jungh.) Imazeki is currently used for various morphologically and ecologically different specimens occuring mainly in temperate or boreal Japan (Ota & Hattori 2008). The basionym of this taxon, *Polyporus miniatus* Jungh., was described from tropical Asia (island of Java). Moreover, Corner's specimens of *L. sulphureus* var. *miniatus* from Papua and the Solomon Islands (Corner 1984) are characterized by basidiospores significantly narrower [4–5.5(–5.7) × 3–3.7 µm] than those of the European taxa. Therefore the conspecificity of the Japanese temperate–boreal *Laetiporus* specimens growing on coniferous trees and *L. sulphureus* var. *miniatus* sensu typi is improbable. According to the above evidence the re-description and typification of *Laetiporus montanus* is proposed.

Laetiporus montanus Černý ex Tomšovský & Jankovský, **sp. nov.** FIGURE 2

MYCOBANK : MB 512119

Species haec a Laetiporo sulphureo *basidosporis late ovoideis, (5.8) 6.0–8.0 (9.0) × (3.8) 4.0–5.5 µm differt. Habitat ad substrato arboribus coniferis (*Picea, Larix*) in partibus montanis Europae Centralis.*

HOLOTYPUS: Czech Republic, Jeseníky Mts., Praděd national nature reserve, valley of the Bílá Opava brook, 50°4'28.35"N; 17°14'41.17"E, on stump of *Picea abies*, 1230 m a.s.l., 27 July 2006, leg. L. Jankovský, BRNM 706688.

ETYMOLOGY: from the Latin *montanus* = occurring in mountains.

PREVIOUSLY PUBLISHED DESCRIPTIONS AND ILLUSTRATIONS: Černý (1989, Parazitické dřevokazné houby: 45–47).

KEY CHARACTERS – Basidiocarps annual, shelf-shaped, dimidiate, sessile to stipitate, up to 30 cm wide, projecting 3–20 cm and 1–3 cm thick. Upper surface of basidiocarp bright orange, fading to pale brownish with age; context pale yellow; pore surface bright sulphureous yellow to pale tan with age; pores angular, 1–4 per mm, with thin dissepiments that become lacerate; tube layer 2–4 mm thick. Hyphal system dimitic; generative hyphae rarely apparent in the context, thin-walled, hyaline, simple-septate with rare branching, 4–8 µm in diam. Contextual binding hyphae firm to thick walled, hyaline, nonseptate, much branched, 5–13 µm in diam; tramal hyphae thin to thick walled, simple-septate with occasional branching, 3–6 µm in diam. Basidia pyriform,

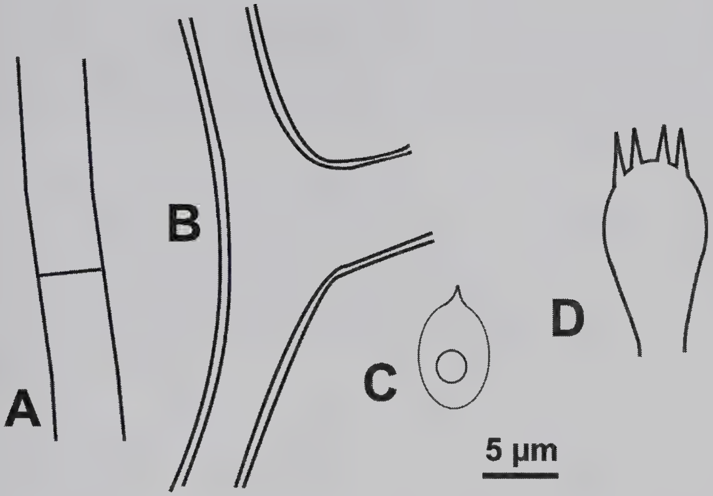

FIGURE 2. Microscopic characters of *Laetiporus montanus*.
A – thin-walled generative hypha; B – contextual binding hypha; C – basidiospore; D – basidium.

4-sterigmatic, 12–25 × 6–8 µm. Basidiospores broadly ovoid, (5.8) 6.0–8.0 (9.0) × (3.8) 4.0–5.5 µm, hyaline, thin-walled, smooth, negative in Melzer's reagent, usually with globose oil drop, 1–3 µm in diam. For microscopic characters, see FIG.2.

ECOLOGY, DISTRIBUTION – *Laetiporus montanus* occurs on mature and overmature conifers (*Picea abies* and *Larix decidua*) in mountain areas of Central Europe. The species seems to be restricted to the elevation above 1100 m a. s. l. and to stands of indigenous coniferous trees. The currently known distribution is restricted to two localities in the Czech Republic: Jeseníky Mts. (Altvatergebirge in German) and Bohemian Forest (Šumava Mts. in Czech; Böhmerwald in German), to High Tatra Mts. in Slovakia, and large areas in the Austrian Alps. In the Czech Republic, the occurrence *L. montanus* is strictly restricted to autochthonous montane spruce stands and natural range of *Picea abies.*

REPRESENTATIVE SPECIMENS EXAMINED – ***Laetiporus montanus:*** **CZECH REPUBLIC:** Jeseníky Mts., Praděd national nature reserve, 1320 m a.s.l., *Picea abies*, 27.VII.2006, leg. L. Jankovský, holotype, BRNM 706688, isotype BRNL. - Bohemian Forest (Šumava Mts.), Plechý Mt., 1340 m a.s.l., *Picea abies,* 15.VII.1998, leg. J. Holec, PRM 897053. - Bohemian Forest (Šumava Mts.), Trojmezná Mt., 1270 m a.s.l., *Picea abies,* 13.VII.2006, leg. V. Pouska, BRNM 706697. **SLOVAKIA:** High Tatra Mts., Popradské Pleso Lake, ca.1400 m a.s.l., *Larix decidua*, 30.VII.1987, leg. A. Černý, BRNL. **AUSTRIA:** Upper Austria, Burgtall, Wurzeralm, 1700 m a.s.l., *Larix decidua*, 17.IX.1989, leg. H. Forstinger, LI. - Styria, surroundings of Oberwölz, 2000 m a.s.l., *Larix decidua*, 30.V.1971, leg. H. Forstinger, LI.

Laetiporus sulphureus: CZECH REPUBLIC: Tišnov town, *Prunus domestica*, 3.X.2006, leg. L. Jankovský, BRNM 706687. - Českosaské Švýcarsko National Park, Mezní louka, host not indicated, 3.VII.2003., leg. A. Vágner, BRNM 686283. - Orlické Mts., Bukačka protected nature area, 1000 m a.s.l., *Sorbus aucuparia,* 1.IX.2006, leg. J. Moravec, BRNM 706696. - Beskydy Mts., Komorní Lhotka village, 415 m a.s.l., *Larix decidua,* 3.VI.2006, leg. J. Lederer, BRNM 706686.

Comments – The distribution of *Laetiporus montanus* is poorly known. The species occurs probably not only in Austria but also in Switzerland (Rogers et al. 1999) and other adjacent Alpine countries. Its presence in other European mountain areas with indigenous *Picea* and *Larix* is possible. In contrast, misidentifications of *L. sulphureus* specimens fruiting on planted conifers at lower elevations are possible (e.g. BRNM 706686), even though the two species are distinguishable according to basidiospore measurements – the length of *L. sulphureus* basidiospores usually does not exceed 7.0 µm.

The occurrence of *L. montanus* in Asia, mainly in Siberia, the Russian Far East and northern Korea or Japan is possible. There may be rich populations of this or a closely related species occurring in east Palaearctic regions with natural stands of coniferous trees. Therefore a study of conifericolous *Laetiporus* from these regions is desirable.

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Two little known gasteroid fungi from Santa Catarina State, southern Brazil

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Abstract — *Geastrum ovalisporum* and *Tulostoma rickii* are reported for the first time from the State of Santa Catarina in southern Brazil. *Geastrum ovalisporum* is characterized mainly by ovoid basidiospores, a unique feature in the genus. *Tulostoma rickii*, a rare and poorly known species from Rio Grande do Sul State, is diagnosed by its bulbous (pseudo-volvate) stipe base and reticulate basidiospores. Illustrations (including scanning electron micrographs of the basidiospores) accompany full taxonomic descriptions and distributional notes.

Key words — *Geastraceae*, *Tulostomataceae*, Neotropical mycobiota

Introduction

The study of the gasteroid mycobiota of Santa Catarina State dates from the mycological contributions of the European naturalists who explored Brazil in the past centuries, such as E. Ule and A. Möller (Fidalgo 1965). The latter studied species of phalloids, including the new genera *Blumenavia*, *Itajahya*, and *Protubera*, which were based on specimens collected in Santa Catarina (Möller 1895). Viégas (1945) reported two unidentified species of *Cyathus* and *Lycoperdon* for the State. More recently, Giachini et al. (2000) surveyed the ectomycorrhizal fungi associated to exotic *Pinus* and *Eucalyptus*, reporting 23 gasteroid fungi, including three new species, and Sobestiansky (2005) reported collections of *Geastrum triplex* Jungh. and *Sphaerobolus* sp. The discussion of two noteworthy and poorly known species found near the Rio Grande do Sul border is aimed at improving the knowledge of gasteroid fungi in Santa Catarina State.

Materials and methods

Specimens were collected in the State of Santa Catarina, southern Brazil, near Rio Grande do Sul border, and kept at the SMDB herbarium. Morphological studies were performed according to Miller & Miller (1988). The color terminology used is that of Kornerup & Wanscher (1978). Line drawings of the microstructures were made with the aid of a drawing tube. Scanning electron microscopy (SEM) studies were performed with a Phillips XL30; basidiospores were mounted on aluminum stubs and coated with 10–15 nm of gold using a standard sputter.

Taxonomy

Geastrum ovalisporum Calonge & Mor.-Arr.,
Bol. Soc. Micol. Madrid 25: 273, 2000. FIG. 1-4

Basidiomata 30–36 mm high, 22–26 mm diam, epigeous at maturity (eggs not seen). Exoperidium fornicate (KW 5F5), non-hygroscopic, splitting in 7 unequal rays; mycelial layer encrusted with debris; fleshy layer brown (KW 5F4), sloughing away to reveal a fibrous layer. Endoperidial body 12–14 mm diam, subglobose, dark brown (KW 7F4), pedicellate (2–3 mm high) and with a distinct hemispheric apophysis. Peristome fimbriate to slightly striate and conical, well delimited by a circular and slightly depressed area in the centre of the endoperidium, dark brown (KW 6F4). Gleba pulverulent when mature, dark brown (KW 7F4).

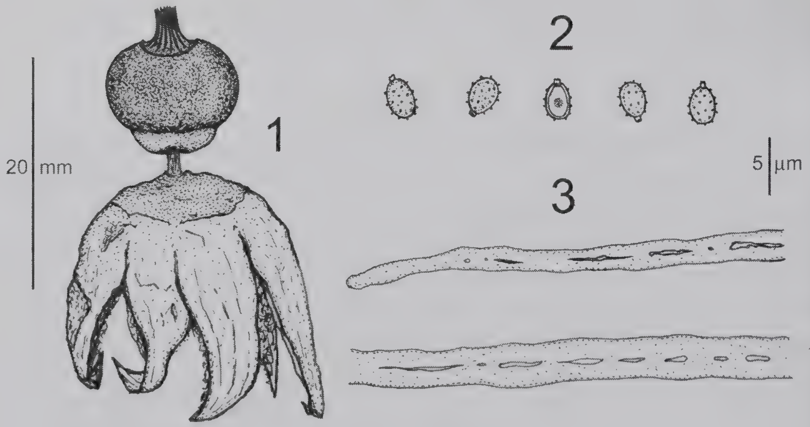

FIG. 1-3. *Geastrum ovalisporum*.
1. Basidioma. 2. Basidiospores. 3. Capillitium.

Basidiospores 3–3.5 × 2–2.5 *μ*m diam (incl. ornamentation), ovoid to subglobose, pale brown under KOH, with a small verrucose ornamentation, short tubular pedicel present, under SEM the ornamentation is strongly verrucose. Capillitium formed by 2–5 *μ*m diam hyphae, with yellowish, thickened walls, lumen much reduced or absent.

Examined specimen: BRAZIL. Santa Catarina State, municipality of Mondaí, 12.X.1995, *leg. A.A. Spielmann* (SMDB 11.522); on soil and litter in subtropical forest.

Discussion: Calonge et al. (2000) described *Geastrum ovalisporum* with the following diagnostic characters: non-hygroscopic exoperidium, stipitate endoperidium, fimbriate peristome, and ovoid basidiospores, which are unique in the genus. The collected specimens were found growing on litter and subtropical rainforest soil, in contrast to the Bolivian holotype, which was collected on sandy soil in tropical forest. Leite et al. (2007) recently reported *G. ovalisporum* for the first time from Brazil (in Rio Grande do Norte State) on soil with woody debris. This is the first report of *G. ovalisporum* from southern Brazil.

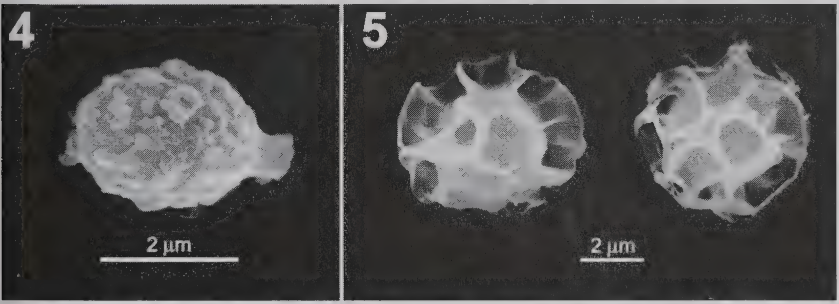

Fig. 4-5. Basidiospores under SEM.
4. *Geastrum ovalisporum*. 5. *Tulostoma rickii*.

Tulostoma rickii Lloyd, The Tylostomeae: 20, 1906. Fig. 5-8
= *T. bulbillosum* Bres., Broteria 5: 28, 1906.

Basidiomata 56–81 mm high, epigeous. Endoperidial body 18–23 mm diam, subglobose. Exoperidium membranous, light orange (KW 5A5) to yellowish brown (KW 5D8), encrusted with soil particles and thus with a verrucose surface. Endoperidium membranous, light orange (KW 5A4), adhered to the exoperidium. Peristome fibrillose, almost indistinct. Socket conspicuous to inconspicuous, with a membranous consistency, scaly. Gleba pulverulent when mature, brownish yellow (KW 5C7) to golden brown (KW 5D7). Stipe 42–71 × 5–7 mm, slightly sinuous, with longitudinal striae, scaly surface, light orange (KW 5A5) to yellowish brown (KW 5D6), base volviform with abundant soil particles adhered, hollow with white flesh.

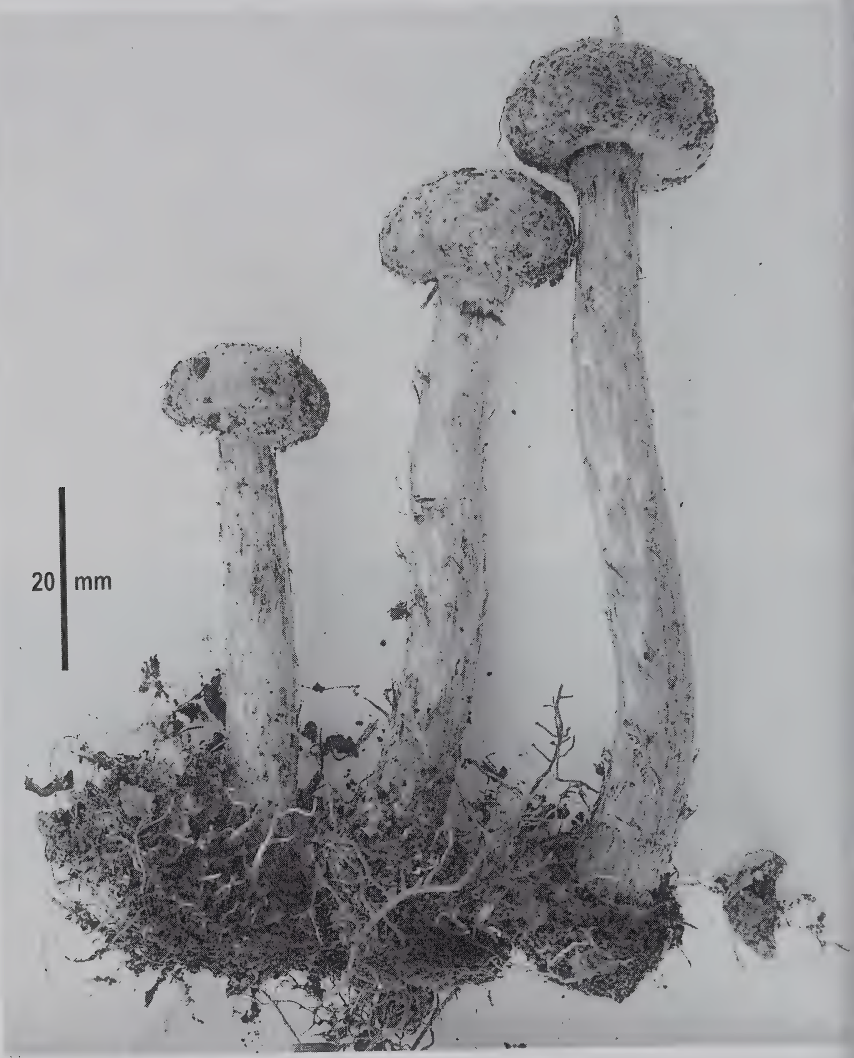

Fig. 6. Basidiomes of *Tulostoma rickii*.

Basidiospores 4.2–5 μm diam (excl. ornamentation) or 6.7–8.4 μm (incl. ornamentation), globose, distinctly clathrate and appearing with 'wings' or false 'spines' in optical section. Capillitium hyphae 4.2–8.4 μm diam with thickened walls, hyaline to stramineous, septate.

Examined specimen: BRAZIL. Santa Catarina State, municipality of Riqueza, 27.XII.2006, *leg. A.A. Spielmann & M.A. Sulzbacher 86* (SMDB 10.999); growing on humic soil, among roots, in subtropical rain forest.

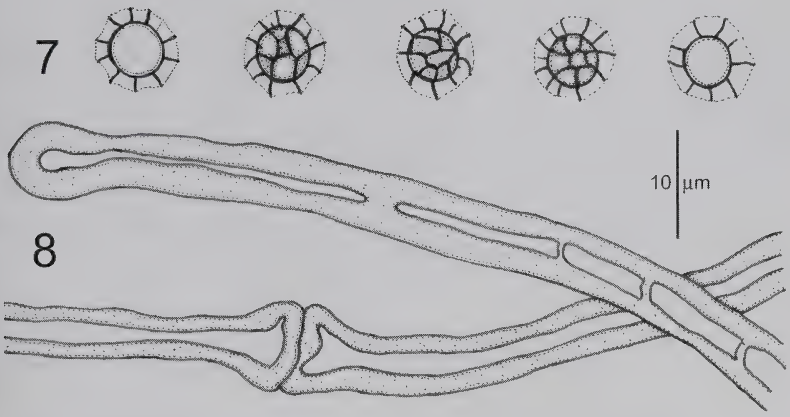

Fig. 7-8. *Tulostoma rickii.*
7. Basidiospores. 8. Capillitium.

Discussion: The following *Tulostoma* species have been reported from Santa Catarina State: *T. cyclophorum* Lloyd and *T. exasperatum* Mont. (Wright 1987). *Tulostoma rickii* is diagnosed by the presence of a bulbous stipe base that resembles a pseudovolva, and reticulate basidiospores (Wright 1987). The basidiospores are similar to those of *T. exasperatum*, which is, however, lignicolous in contrast to *T. rickii,* which occurs on rainforest soils. Wright (1987) also considered *T. rickii* a rare *Tulostoma* species reported only from Rio Grande do Sul in Brazil and from Argentina. This is the first report from Santa Catarina.

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Validation and typification of the name *Claviceps zizaniae*

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Abstract — The binomial, *Claviceps zizaniae*, has not previously been validly published. The basionym, *Spermoedia zizaniae*, was improperly neotypified and is here lectotypified and that type is epitypified. The history of the discovery and description of this ergot fungus on wild rice, *Zizania aquatica*, and the roles of the main contributors, Faith Fyles, Charles M. Wright, Ibra Conners and Maria Pantidou, are outlined.

Key words — Cornell, DAOM, nomenclature, sclerotia, teleomorph

Introduction

Claviceps zizaniae is the commonly used name for the fungus forming ergot on the wild rice species, *Zizania aquatica* L. and *Z. palustris* L. (Aiken et al. 1988, Conners 1967, Dore 1969, Farr et al. 1989, Ginns 1986, Kernkamp et al. 1976). Phylogenetically, *C. zizaniae* continues to be an accepted, well defined taxon (Alderman 2003, Alderman et al. 2004, Pažoutová et al. 2004, 2008). Data-basing of archived specimens in the Canadian National Mycological Herbarium (DAOM, see Holmgren & Holmgren 1998) revealed the existence of both a purported 'neotype' and 'original material' for the basionym, *Spermoedia zizaniae* Fyles (Fyles 1920b). Further investigation led to the realization that the basionym should not have been neotypified (Pantidou 1959) and that the combination in '*Claviceps zizaniae* (Fyles) Pantidou' (Pantidou 1959) has been invalid until now.

History

Ergot on wild rice in North America has long been known to aboriginal peoples, such as the Ojibwa, who apparently referred to it in words meaning "frozen rice" (Jenks 1901) or "frozen kernels" (Denniston 1900). The earliest record in technical literature was by Trelease (1886), who differentiated the

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ungerminated, pinkish brown, stout, ovoid sclerotia of *Claviceps* sp. on *Zizania aquatica* in Wisconsin from common ergot (*Claviceps purpurea* (Fr.) Tul.) on other grains. The next report in the literature by Farlow & Seymour (1888) is traceable to Trelease's report via the publication by Farlow & Trelease (1887). Unaware of Trelease's 1886 report, Fyles (1915) cited Denniston's 1900 report of *Claviceps purpurea* ergot on *Zizania aquatica* as the earliest record. Fyles (1915) was the first to overwinter and induce germination of the sclerotia in order to view the characteristically stalked stromatal heads with fertile perithecia and asci characteristic of a *Claviceps*. Additionally, she performed inoculation studies demonstrating that the *Claviceps* on *Zizania* only infected *Zizania* and did not infect normal hosts for *C. purpurea* (that she called *Spermoedia clavus* (DC.) Fr.), i.e. *Agropyron tenerum* Vasey (= *Elymus trachycaulus* (Link) Gould ex Shinners), *Alopecurus pratensis* L., *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl, *Dactylis glomerata* L., *Poa pratensis* L. and *Elymus dasystachys* Trin. (= *Leymus secalinus* (Georgi) Tzvelev). Notably, Fyles (1915) also mentioned that the sclerotia from wild rice floated, which is biologically significant for a swamp inhabiting fungus (Alderman et al. 2004, Brown 1947). At the end of her publication, Fyles (1915) promised to provide a formal description and name for the fungal species elsewhere. As noted by Pantidou (1959), Fyles never did provide a more formalized description, however in her subsequent bulletin on wild rice, Fyles (1920b) repeated some of the information and photographs, and on page 17 named the fungus *Spermoedia zizaniae* with a further citation of her earlier publication in a footnote. Publication of the species in *Spermoedia* Fr. rather than in *Claviceps* Tul. was, as commented upon by Pantidou (1959), undoubtedly influenced by the classification published by Seaver (1911), who treated *Claviceps* as a synonym of *Spermoedia*. In her bulletin on poisonous plants, Fyles (1920a) adopted the name *Spermoedia clavus* with *Claviceps purpurea* in synonymy, when she described ergot of rye. Also revealing her mindset was the fact that in 1915 she had stated that *Claviceps microcephala* (Wallr.) Tul. was "now" called *Spermoedia microcephala* (Wallr.) Seaver.

Pantidou (1959) correctly noted that Art. 59, then, and even today (McNeill et al. 2006: 59.2 & Ex 5), leads to the interpretation of Fyles' name, "*Spermoedia zizaniae*", as a teleomorphic name because she included a description of the teleomorph complete with descriptions of asci, ascospores and perithecia. It was Pantidou's work, done in collaboration with Dore who was working on wild rice (Dore 1969), that precipitated modern acceptance of the fungus as a distinct species. Unfortunately, the combination, *Claviceps zizaniae* proposed by Pantidou (1959) was invalidly published, in contravention of Art. 33.4. Although Pantidou cited *Spermoedia zizaniae* Fyles (1920b) as the basionym, she failed to provide a full and direct reference to the place of publication (Fyles 1920b: 17). Fyles' (1920b) publication, where the name was validated, was a discussion on wild rice and therefore cannot be interpreted as publication coextensive with the protologue for the fungal name (Art. 33, Note 1). Technical validation is provided below.

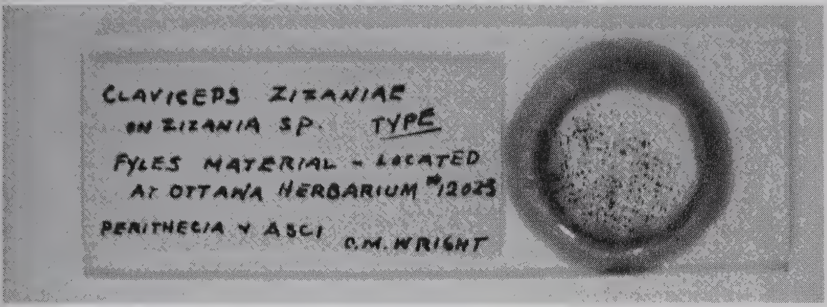

FIG. 1. Slide prepared by C. Wright from original Fyles material of *Spermoidea zizaniae* DAOM 12023.

Pantidou (1959) also designated a 'neotype' for the name (DAOM 56855 [= Dore # 17042]), which was further illustrated in the publication by Dore (1969: 62, as Dore # 17042, in situ). Although this proposed typification has provided stability to the usage of the name *C. zizaniae*, designation of it was also an error, because it consisted of two elements, the original sterile sclerotia and perithecia induced 2 years later. A neotype may only be designated when no original material exists (Art. 9.6). Illustrations, such as those provided by Fyles (1915, 1920b) can be designated as types (Art. 9.2) and can constitute original material as defined by Art. 9, Note 2. Hence, the designated 'neotype' is to be superseded (Art. 9.17). Additionally, there is other original material to select from as is explained below.

Faith Fyles was an assistant botanist under Hans Güssow, the Dominion Botanist at the Department of Agriculture (Lloyd 1961) in Ottawa. Some of her materials remained with the department in Ottawa. For some years, the importance of her work demonstrating host specificity was underestimated by others who went on to identify ergot of *Zizania* as *Claviceps purpurea* (Conners 1931, 1938, Sprague 1950, Wehmeyer 1950).

In 1940, the wild rice ergot was discovered on *Zizania* in Maine, USA, by the botanist, Steinmetz (1940), leading to a student's Master's thesis (Wright 1942) and a published abstract for a meeting of the American Phytopathological Society, which, however, was cancelled because of World War II (Steinmetz & Wright 1943). The teleomorph of *Claviceps zizaniae* was once again germinated from sclerotia and a dipterous vector, *Oscinella neocoxendix* Sabrosky [now *Apallates neocoxendix* (Sabrosky)], was identified (Steinmetz & Wright 1943). The host specificity was confirmed, i.e. the ergot fungus from *Zizania* would only infect

Zizania and not barley, oats, wheat, or millet, while *Claviceps* from *Festuca*, *Calamagrostis*, *Agropyron*, and *Dactylis* would not infect *Zizania*. Evidently the latter publication led to correspondence between Ibra Conners, in Ottawa, and C. M. Wright, then a student of Prof. Patrick Fitzgerald at Cornell University. In a letter filed in DAOM with specimens, dated July 30, 1944, Wright thanked Conners for sending Fyles' material, noting that he was returning it undivided at the suggestion of Fitzpatrick, and that he was including a slide of a macerated perithecial head plus his germinated sclerotium from the material in Maine. On file in DAOM are the specimen of germinated sclerotium sent by Wright (DAOM 239767) and the slide of the macerated perithecial head he prepared from Fyles' original specimen (DAOM 12023), specifically noting on the slide label "Ottawa Herbarium 12023". The actual germinated sclerotium/sclerotia with perithecial heads that Fyles labeled *Spermoedia zizaniae* and which were sent to Wright cannot be located in DAOM. However, the DAOM accession book records for 12023 "on *Zizania aquatica* L. Ottawa June 30, 1914 F. Fyles F.F." Notably, June 1914 was the last month that Fyles (1915) recorded for maturation of the perithecia on germinated sclerotia collected in Ottawa and overwintered in Ottawa. Hence, the squash mount of DAOM 12023 (Fig. 1) is considered to be original material. However, given its poor state of preservation, we prefer to designate the illustration (unnumbered plate on p. 18, Fyles 1920b) as lectotype, rather than the slide, and further to choose the portion of the 'neotype' selected by Pantidou (1959) that bears perithecia [designated as DAOM 56855(b)] as the epitype to the lectotype. We purposely do not choose pl. XI from Fyles (1915) because it is a collage of photographs, possibly from different dates, whereas the 1920 photograph constitutes a single photographic plate. We differentiate the original collection of sterile sclerotia collected by Dore as DAOM 56855(a) — see below.

Charles Wright had indicated in his letter to Ibra Conners that he intended to publish the combination in *Claviceps* in Mycologia but for unknown reasons, no such combination was made in Mycologia (or elsewhere) nor did any publication by Wright concerning *Claviceps* ever appear in Mycologia. Instead he went on to study viral diseases in tomatoes and cherries (Wright 1947, Blodgett & Wright 1948). Of historical significance is a specimen by Wright (CUP 31718) and photographs (CUP 31717, 31719–31721) deposited at Cornell University bearing labels with the name "*Claviceps zizaniae* (Fyles) Wright" (K. Hodge, curator CUP, pers. comm. 2008) and the slide of Fyles' specimen he returned to DAOM bore the binomial "*Claviceps zizaniae*". However, not until Pantidou (1959) published her paper on *Claviceps zizaniae* did the species became generally accepted as distinct from *C. purpurea* by Conners (1967) and later authors and host indices compilers. Then the name *Claviceps zizaniae* came into usage.

In order to preserve this oft-cited link to the literature, we propose the following combination.

Nomenclature

Claviceps zizaniae (Fyles) Pantidou ex Redhead, M.E. Corlett & M.N.L. Lefebvre, **comb. nov.** FIG. 1

MYCOBANK MB512148

BASIONYM: *Spermoedia zizaniae* Fyles, Wild rice. Dominion Experimental Farm, Canad. Dept. Agric., (2nd ser.) Bull. 42: 17. 1920.

"*Claviceps zizaniae* (Fyles) Wright", nom. herb. (CUP), nom. inval. (Art. 29.1).

"*Claviceps zizaniae* (Fyles) Pantidou", Can. J. Bot. 37: 1234 (1959), nom. inval. (Art. 33.4).

LECTOTYPUS for *Spermoedia zizaniae* (**here designated**): Dominion of Canada. Dominion Experimental Farm, Dept. Agric., Bull. 42 (2nd ser.): **unnumbered photograph (p. 18)** (Fyles 1920b) {teleomorph}.

Photographed material, although published in 1920, is presumed to represent overwintered sclerotia originally harvested with seed of *Zizania aquatica*, Sept. 29, 1913, Treadwell [45° 35' 49" N - 75° 00' 38" W], Ontario, Canada, and variously treated in Ottawa to induce germination as outlined by Fyles (1915). Fyles (1920b) indicated that work on wild rice, itself, was halted after her 1913–14 research until 1917 after which year wild rice access was indirectly curtailed because gatherers had gone to the 1st world war front [1914–18]. The only other collection associated with Fyles in DAOM was DAOM 35777, on wild rice from Shediac, New Brunswick, Canada, Oct. 14, 1914 ["14/10/14"] based upon sclerotia only, and originally labeled *Claviceps purpurea* in pencil, written over in Indian ink, with the species epithet crossed out and replaced by "*zizaniae* (Fyles) Pantidou", obviously relabeled concurrently with or after Pantidou's publication.

EPITYPUS (**here designated**): **DAOM 56855(b)**, harvested 20 Feb. 1959, perithecia on stroma germinated after soaking sclerotia in sterile water in June 1958, refrigerated until November, and transferred to sterile sand in greenhouse, using sclerotia originally collected on *Zizania aquatica* var. *interior*, in swamp woods, about 2 miles NW of Sheffield, New Brunswick, Canada, 9 Sept. 1957, W.G. Dore 17042 [sclerotia filed as DAOM 56855(a)]. See Pantidou (1959) for additional details.

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Revision of *Scutellospora* and description of five new genera and three new families in the arbuscular mycorrhiza-forming *Glomeromycetes*

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Abstract — Arbuscular mycorrhizal fungi forming spores on bulbous sporogenous cells were earlier organized in two genera of the *Gigasporaceae*: *Gigaspora* and *Scutellospora*. Molecular analyses indicated that *Scutellospora* is polyphyletic. The *Gigasporaceae* are revised on the basis of morphological spore characters and 18S and 25S rRNA gene sequences, and the 36 *Scutellospora* species are reorganised in three new families including five new genera: *Scutellosporaceae (Scutellospora)*, *Racocetraceae (Racocetra, Cetraspora)* and *Dentiscutataceae (Dentiscutata, Fuscutata, Quatunica)*. The family *Gigasporaceae* remains with a single genus *Gigaspora*. The molecular data indicate that the genus *Gigaspora* derived from within the former genus *Scutellospora*. The family *Scutellosporaceae* forms the most ancestral clade, while *Gigasporaceae* are phylogenetically not much distant from *Racocetraceae* and *Dentiscutataceae*. Keys are presented for the identification of all species of the reorganized former *Gigasporaceae*.

Key words — *Glomeromycota*, *Diversisporales*, germination shield, ontogeny, phylogeny

Introduction

Arbuscular mycorrhizal fungi (AMF), which form spores terminally on bulbous sporogenous cells, were described in the family *Gigasporaceae* (Morton & Benny 1990) of the order *Diversisporales*, *Glomeromycetes* (Cavalier-Smith 1998). In this family, with about 40 species, spores are relatively big, generally >200 µm and up to 700–1050 µm in diameter. Besides having this typical spore formation, species of the *Gigasporaceae* also differ morphologically from other families of the *Glomeromycetes* by not forming intraradical vesicles but instead so-called auxiliary cells in the extraradical mycelium (Gerdemann & Trappe 1974, Morton & Benny 1990). Two genera have been taxonomically recognized based on spore wall characteristics and germination structures: *Gigaspora* and *Scutellospora* (Walker & Sanders 1986, Morton & Benny 1990). Spores of *Gigaspora* spp. differentate a single spore wall and multiple germ warts on the inner wall layer (= single wall group sensu Walker 1983), and *Scutellospora* spp. form two to four spore walls and a discrete germination compartment (the so-called germination shield) on the innermost wall. The spore wall structure, spore ontogeny and development of the mycorrhizal mycelia in *Scutellospora* were precisely described by Franke & Morton (1994), Morton (1995), de Souza & Declerck (2003), Declerck et al. (2004), de la Providencia et al. (2005) and de Souza et al. (2005).

The last publication unequivocally showed through molecular-based phylogenetic analyses that *Scutellospora* is polyphyletic, a finding that was also evident in other recent articles (e.g., Walker et al. 2004, Ahulu et al. 2006, Redecker et al. 2007). However, de Souza and co-workers found a disagreement between morphological based and molecular cladistic analyses that they could not resolve.

The objective of this study was to look at common morphological features of the spores of all species in the genus *Scutellospora* and to search for morphological conformity and differences, and to find common morphological features of spores for the species that were congruent with the rRNA-based molecular phylogenetic reconstruction. We concentrated our investigation on spore morphology because spores are the basis for species diagnosis in AMF. We had access to several collections of spore specimen of *Scutellospora* spp. Specimens with mycelium and in particular auxiliary cells in the root external mycelium were seldom available from species described of the *Gigasporaceae*, so that we did not consider these fungal parts in our investigations. According to Walker & Sanders (1986) the morphology of the auxiliary cells does not show much variability in *Scutellospora* anyway.

We analyzed type or isotype specimens of almost all described *Scutellospora* spp. and present germination shields of 31 species in colored photographs. We found that there are common morphological spore features in *Scutellospora* that are congruent with the molecular phylogenetic groups based on rRNA genes. The corresponding morphological and molecular groups are hereafter presented first. According to these groups, we then emend the family *Gigasporaceae*, reorganize the currently known species of *Scutellospora* taxonomically into three new families and six genera of the *Diversisporales*, and transfer 25 species of the *Scutellospora* genus into five new genera.

Material and methods

Specimen analyses

The *Scutellospora* specimens analyzed, their provenance and locations are listed in TABLE 1. In particular ex type, isotype and paratype material were examined, and we had access to several herbaria and private collections of arbuscular mycorrhizal fungi (e.g., OSC, FH, URM (Recife, Brazil), Embrapa Agrobiologia (Seropédica, Brazil), DCS-UFLA (Lavras, Brazil), International Culture Collection of Arbuscular and Vesicular-Arbuscular Mycorrhizal Fungi (INVAM), and personal collections held by Sieverding, Oehl, de Souza, Trappe, Spain, Błaszkowski, Cuenca, and C. Castillo). Additionally, all original species descriptions and published species emendations were also considered.

During a visit at INVAM, F. Oehl analyzed stored vouchers of the following species: *S. arenicola*, *S. biornata*, *S. calospora*, *S. cerradensis*, *S. coralloidea*, *S. dipurpurescens*, *S. erythropus*, *S. fulgida*, *S. gregaria*, *S. heterogama*, *S. pellucida*, *S. persica*, *S. reticulata*, *S. rubra*, *S. scutata*, *S. verrucosa*, *S. weresubiae*. Spores of the following species were isolated from living culture accessions at INVAM and permanently fixed on microscope slides before analyzing: *S. calospora*, *S. coralloidea*, *S. dipurpurescens*, *S. erythropus*, *S. fulgida*, *S. heterogama*, *S. persica*, *S. verrucosa*.

Older specimens (mounted on microscopic slides before 1990) had generally been mounted either in lactophenol, while other specimens were fixed with polyvinyl alcohol-lactic acid-glycerol (PVLG) or in a mixture of PVLG + Melzer's reagent, which has become the major fixing media since 1990 (e.g. Brundrett et al. 1994). We fixed newly mounted spores from the collections using those two recent mountant media. When available, spores freshly isolated from soils were also mounted in PVLG or in PVLG + Melzer's reagent and sometimes also in a mixture of lactic acid to water at 1:1, in Melzer's reagent, and in water. Spore walls, germination structures and all other mycorrhizal structures were analysed using compound microscopes at 100–630× magnification. Most photographs presented in this paper were taken with a digital camera (Olympus model DP70-CU) on a Zeiss Axioplan compound microscope. A few photographs were taken by F. Oehl at INVAM or at OSC. The legends and scales on the photographs of the figures were inserted with Adobe Photoshop CS2 9.0.

Spore wall terminology

The terminology of the spore walls in our paper differs from the nomenclature for walls followed by Morton (1995) and Silva et al. (2006b) in *Scutellospora* (see also INVAM's homepage: www.invam.caf.wvu.edu). INVAM and Silva et al. (2006b) differentiate two to four walls: the spore wall (SW) and one to three germinal walls (GW1, GW2 and GW3), each with different layers. This nomenclature is misleading because in the *Gigasporaceae* spore germination always starts from the innermost layer of the innermost wall, from which we conclude that spores have only one germinal wall, and not several. Thus, we adopt the wall terminology we used for other AMF genera (e.g. Oehl & Sieverding 2004, Oehl et al. 2006, Spain et al. 2006, Palenzuela et al. 2008) for *Scutellospora* species: INVAM's 'spore wall' (SW) is termed here the 'outer spore wall' (OW) while INVAM's GW_n (where n = 1–3) we call 'middle wall(s)' (MW_n, where n=1–2) and 'inner wall' (IW). Our IW always is the germinal wall in all *Scutellospora* spores, as a germination shield is formed on the surface of this wall or between a thin outer layer and subsequent layers of the IW.

TABLE 1. Examined specimens from type and non-type material representing 36 *Scutellospora* spp.

SPECIES NAME	TYPE MATERIAL	NON TYPE MATERIAL (COLLECTION)
Scutellospora alborosea	Holotype IBACC 1-Herrera/Ferrer-HAC, isotypes IBACC 2-5-Herrera/Ferrer-HAC;	
S. armeniaca	Type, ex type (Błaszkowski collection)	Specimens from Germany, France, Switzerland (Oehl)
S. arenicola	Holotype OSC #49'586; isotype 2374 at FH	Specimens deposited at FH and INVAM; specimens from Germany (Oehl)
S. auriglоba	Photographic type collection (Hall & Abbott 1979)	Specimens from Chile (Castillo), specimens from Brazil (Oehl)
S. biornata	Isotype #49'583, ex type (Sieverding collection), ex type (Spain collection)	Specimens at INVAM; specimens from Brazil (Oehl)
S. calospora	Type at FH	Specimens at INVAM; pure culture isolate from Bötzingen, Germany (Oehl)
S. castanea	Holotype OSC #83'344	Pure culture isolate BEG1; specimens from Germany and Switzerland (Oehl)
S. cerradensis	Holotype OSC #55'838; ex type (Spain collection)	Specimens at INVAM; specimens from Brazil and Benin (Oehl)
S. coralloidea	Holotype OSC #31'026, paratype OSC #31'025	Specimens at INVAM, and from Brazil (de Souza)
S. crenulata	Ex type (Gisela Cuenca collection, Oehl collection)	
S. dipapillosa	Holotype OSC #45'839; paratype OSC #45'848	Specimens from Colombia (Sieverding)
S. dipurpurescens	Holotype OSC #83'343, ex type INVAM	Specimens at INVAM; Specimens from Chile (Castillo), Germany and Switzerland (Oehl)
S. erythropus *	Holotype OSC #41'527	Specimens at INVAM; ex INVAM (Oehl)
S. fulgida	Holotype OSC #46'722; isotype 505 FH	Specimens at INVAM; specimens from Brazil (Oehl)
S. gilmorei	Holotype OSC #30'990; paratype OSC #31'018; paratype OSC #30'921	Specimens from Colombia (Sieverding)
S. gregaria	Holotype OSC #36'518	Specimens from India (Oehl), and from North America (DCS- UFLA and Embrapa Agrobiologia)
S. hawaiiensis	Type at H907 FH; paratype 807 at FH; isotype OSC; paratypes OSC #53'779 & OSC #53'781	
S. heterogama	Type of basionym *Endogone heterogama* at FH	

* 'erythropa' is a grammatical error for 'erythropus' which is a Greek noun in apposition and not an adjective. It therefore retains the same spelling regardless of the gender of the genus.

TABLE 1, CONCLUDED

S. heterogama sensu Franke & Morton	New type material deposited: Holotype & isotype at URM, isotype OSC #134'504 at OSC & isotype ZT Myc 642 at Z+ZT	Specimens at INVAM; Specimens from Benin, Brazil, Colombia (Oehl; de Souza; Sieverding)
S. minuta	Holotype IBACC 8-Herrera/Ferrer-HAC, IBACC 7; isotypes 9-11-Herrera/Ferrer-HAC	
S. nigra	Holotype OSC #37'516	Specimens from Brazil and Benin (Oehl)
S. nodosa	Holotype , ex type (Błaszkowski collection)	
S. pellucida	Holotype OSC #37'515	Specimens from Germany, Switzerland, Bolivia, Brazil, Benin, Costa Rica, Colombia (Oehl, Sieverding)
S. persica	Holotype OSC #45'837	Specimens at and from INVAM (Oehl); specimens from India (Oehl)
S. pernambucana	Holotype & isotypes at URM (79239-79241), isotypes OSC #134'503, isotypes ZT Myc 641at Z+ZT, ex type (Oehl collection)	
S. projecturata		
S. reticulata	Type OSC #41'174; paratype OSC #47'219	Specimens at INVAM, and from Brazil (Spain; Oehl, Embrapa Agrobiologia, strain CNPAB11)
S. rubra	Ex type material at INVAM	Specimens from Bolivia and Brazil (Oehl)
S. savannicola	Holotype IBACC 22-Herrera/Ferrer-HAC, isotypes IBACC 23-25-Herrera/Ferrer-HAC	Specimens from Benin, Bolivia (Oehl) and Colombia (Sieverding)
S. scutata	Ex type at University Göttingen (Diederichs); isotype at Göttingen University	Specimens at INVAM, specimens from Colombia (Sieverding) and Brazil (de Souza)
S. spinosissima	Ex type (Gisela Cuenca collection, Oehl collection)	
S. striata	Ex type (Gisela Cuenca collection, slides 1642-7 & 1641-3)	
S. tricalypta	Holotype IBACC 26-Herrera/Ferrer-HAC, isotypes IBACC 27-29-Herrera/Ferrer-HAC	
S. trirubiginopa		
S. verrucosa	Holotype OSC #45'838; paratype OSC #45'846	Specimens at and from INVAM; Brazil, Benin (Oehl)
S. weresubiae	Holotype OSC #46'723; paratype OSC #45'845; isotype 440 at FH	Specimens at INVAM

Table 2. Principal morphological spore characteristics in phylogenetic clades A, C1, C2, B1, B2 and B3 (see Plates 2–3; Figs. 10–11)

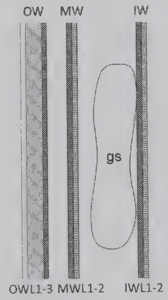
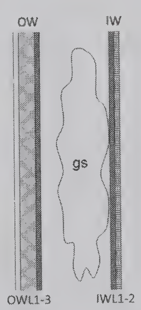
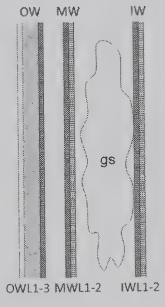
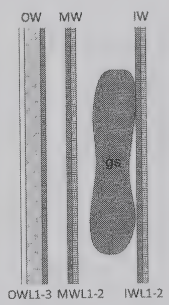
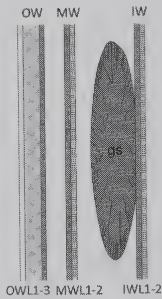
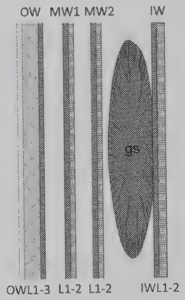
Clade (modified from de Souza et al. 2005)	A	C1	C2	B1	B2	B3
Spore walls						
Number of spore walls	3	2	3	3	3	4
Number of inner walls	2	1	2	2	2	3
Murograph;spore wall structure Abbreviations: gs (germination shield) ow (outer wall) mw (middle wall) iw (inner wall); walls with different layers: l1-3	 OW MW IW gs OWL1-3 MWL1-2 IWL1-2	 OW IW gs OWL1-3 IWL1-2	 OW MW IW gs OWL1-3 MWL1-2 IWL1-2	 OW MW IW gs OWL1-3 MWL1-2 IWL1-2	 OW MW IW gs OWL1-3 MWL1-2 IWL1-2	 OW MW1 MW2 IW gs OWL1-3 L1-2 L1-2 IWL1-2
Walls staining in Melzer's reagent	Species specific: ow, mw, Regularly: iw	Generally ow staining, iw not staining	Species specific: ow, mw Regularly: iw	Species specific: ow, (mw) Regularly: iw	Species specific: ow, mw, Regularly: iw	ow, iw
Species specific outer wall ornamentation types (if present),	Spines, warts, knobs, warts on papillae	Spines, warts, pits only on warts	Spines, or finger-print-like processes in plan view	Spines, minute projections	Spines, sinuous lines, pits, reticula,	Unknown
Species specific outer wall double ornamentation types (if present)	Warts on dome-shaped papillae, spines and papillae	Central pits on warts	Unknown	Unknown	Spines in reticula, pits over sinuous lines, spines on 2 different wall layers	Unknown

Table 2, concluded

Clade	A	C1	C2	B1	B2	B3
Germination shield on outer surface of innermost wall						
Color	Hyaline to light yellow	Hyaline to light yellow	Hyaline to light yellow	Yellow-brown to brown	Yellow-brown to brown	Yellow-brown to brown
Shape and structure	(Mono) to bi-lobed, violin-shaped to cardioid or coiled, generally simple	Oval to ovoid, multiple-wavy-lobed; lobes rounded (curved)	Oval to ovoid, multiple-wavy lobed; lobes rounded (curved)	Violin-shaped to oval, simple -structured	Ellpisoid to oval, circular or heart-shaped, complex structured	Ellpisoid to cardioid, complex structured
Number of lobes or compartments	(One to) two lobes	Multiple small curved compartments, (species specific 4–12)	Multiple small curved compartments, (species specific 4–12)	Two lobes	Multiple compartments (Species-specific 8–30)	Many compartments (8–20)
Folds	Generally very few	Species-specific several to many	Species-specific several to many	Generally very few	Species-specific several to many	Several to many
Rounded germ tube initiations (gti)	Generally (1 or) 2	Species-specific few to several (4–12)	Species-specific few (4–12)	Generally 2	Several to many (8–30)	Several to many (8–20)
Species attributed	*S. arenicola* *S. auriglobа* *S. calospora* *S. crenulata* *S. dipapillosa* *S. dipurpurescens* *S. nodosa* *S. pernambucana* *S. projecturata* *S. tricalypta*	*S. alborosea** *S. castanea* *S. coralloidea* *S. fulgida* *S. gregaria* *S. minuta* *S. persica* *S. verrucosa* *S. weresubiae*	*S. armeniaca* *S. gilmorei* *S. pellucida* *S. spinosissima* *S. striata*	*S. heterogama* sensu Franke & Morton *S. rubra* *S. savannicola* *S. trirubiginopa*	*S. biornata* *S. cerradensis* *S. hawaiiensis* *S. heterogama* *S. nigra* *S. reticulata* *S. scutata*	*S. erythropus*
Genus name applied	*Scutellospora*	*Racocetra*	*Cetraspora*	*Fuscutata*	*Dentiscutata*	*Quatunica*
New family	*Scutellosporaceae*	*Racocetraceae*	*Racocetraceae*	*Dentiscutataceae*	*Dentiscutataceae*	*Dentiscutataceae*

* No germination shield observed in type material

Phylogenetic analyses

The phylogenetic relationship of species in the *Gigasporaceae* was reconstructed by independent analyses of 18S and 25S rRNA genes. Nearly complete sequences of 15 *Scutellospora* spp., seven *Gigaspora* spp. and one *Pacispora* were used to reconstruct the 18S rDNA-based phylogeny. *Pacisporaceae* sequences were chosen as outgroup because it is the closest family to *Gigasporaceae* (Walker et al. 2004). For the 25S rRNA genes partial sequences of 8 *Scutellospora* and 3 *Gigaspora* species were used. In this case, the *Acaulosporaceae* was selected as outgroup, as they were the closest group with sequences available (Silva et al. 2006a). The majority of the sequences were retrieved from public databases, with exception of some *Gigaspora* 18S rDNA sequences that were updated from previous work (de Souza et al. 2004). The sequences were aligned automatically using Clustal X (Thompson et al. 1997). The alignments were further improved by visual inspection and edited using SeaView (Galtier et al. 1996). The phylogeny was reconstructed by Distance, Maximum Parsimony, and Maximum Likelihood criteria using PAUP* version 4.0 Beta 10 (Swofford 2003). For distance (minimum evolution) and maximum likelihood criteria the trees were obtained using heuristic search with likelihood settings from best-fit model selected by Akaike Information Criterion in ModelTest 3.7 (Pousada & Crandall, 1998) and for Maximum Parsimony, the trees were obtained using two ways (1) considering gaps as fifth state or (2) as missing characters. The bootstrap analyses were carried out using 1000 replicates, plus 10 additional replicates per run, by heuristic search with sequences added randomly and branch swapping "tree-bisection and reconnection" as best tree search method. The *Gigaspora* sequences were updated from previous entries (see PLATE 2 for accession numbers) and the alignments generated in this study were deposited in EMBL-EBI nucleotide sequence database (http://www.ebi.ac.uk) under the alignment numbers ALIGN_001298 and ALIGN_001257.

Results

General morphological spore analyses

In order to identify corresponding morphological differences between the genetically different groups (groups A, B and C according to de Souza et al. 2005), we first listed all major spore characteristics of the *Scutellospora* spp. (TABLE 2). Spore size, spore and wall colors, wall ornamentations, numbers of walls, numbers of wall layers, staining features of wall layers and morphology of the germination shield alone were not suitable characters for grouping spores with the molecular clades. Only the number of spore walls combined with the germination shield morphology could be related to the genetically different groups. Additionally, we noticed that the positive staining reaction of the inner wall in Melzer's is somehow linked with the number of spore walls. According to these three major morphological characters, we sub-divided de Souza's groups B and C into sub-groups (B1, B2 and B3, and C1 and C2, respectively). Since germination shield morphology is so important for diagnosing the different groups, we describe their formation and their differences in the following.

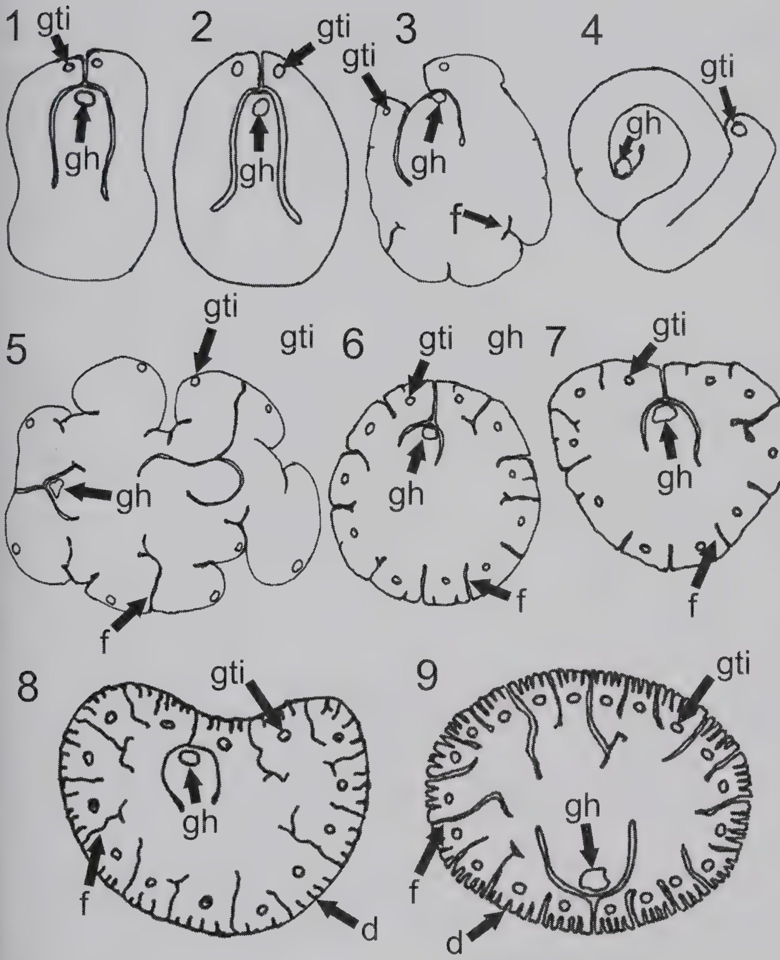


PLATE 1— FIGS. 1–9: CHARACTERISTICS OF TYPICAL GERMINATION SHIELDS. All shields have i) a germination hole (gh) bridging in/on the innermost wall between the spore cytoplasm and the germination shield, ii) a variable number of germ tube initiations (gti) from where germination tubes may start growing, and iii) folds on the shield separating into different lobes and compartments, respectively. FIGS. 1–4. Bi-lobed shields: 1. Violin-shaped. 2. Oval to ovoid shaped. 3. Bi-lobed, with a few folds on the shield wall. 4. Mono-lobed, coiled. FIG. 5. Open organized, wavy shield with multiple small compartments; wavy compartments separated by folds. Each compartment generally has one central gti from where the germ tubes emerge during germination. FIGS. 6–9. Compartmented shields with several to many (8–30) small compartments, separated by folds; each compartment having one gti in its center. Shield shapes circular, cardioid, reniform or ellipsoid. FIGS. 8–9. Highly complex structured germination shields; shield peripheries are conspicuously denticulate.

Morphology of germination shields

Common to all *Scutellospora* spore germination shields (also called "germ shield") is their formation on the inner wall facing the next outermost wall (MW or OW, see TABLE 2). Very seldom does the literature report two germ shields on the same spore. All germ shields initiate from a germination hole (gh) through the innermost IW layer or – more generally – through the innermost spore wall IW (PLATE 1). Walker & Sanders (1986) described the germ shield formation process as an extrusion, with the plasma membrane extending through the hole to form lobes on the IW surface or between a thin IW outer layer and subsequent adherent IW layer. The germ shield size ranges from ca. 35 × 70 µm to about 140 × 160 µm and up to 180 × 280 µm. The germ shield may be divided into one, two, several, or multiple (up to 30) small compartments (sensu Gerdemann & Trappe 1974) that are described below. Each compartment can contain a small, more or less circular (2–5 µm to 12–20 µm in diameter) germ tube initiation (gti, Walker & Sanders 1986, PLATE 1), from which a germination tube starts growing through the overlaying wall layers. Generally, however, only one or two (of 30 gti) actually form a germ tube during germination. Once grown through the walls, the germ tube may begin to branch on or near the spore surface although it often grows straight into the soil. Germ shields are rather more frequent (or at least more easily seen) on older rather than young spores, probably because the shield forms at the end of spore wall differentiation (Franke & Morton 1994, Morton 1995, de Souza et al. 2005). On some species germ shields are readily visible on young mature spores (e.g. *S. dipurpurescens*) whereas they are almost never visible on others (e.g. *S. pellucida*). It should also be noted that, in a very young or early stage of germ shield formation, gti are not visible, suggesting that they may form later in the shield formation process.

In principle, we differentiate the germ shields morphologically by color, spherical shape (including dentate structures), and number and shape of lobes or compartments, each with its own gti. In different species, germ shield size is generally related to spore size and is thus so variable that it is not a good diagnostic character for identifying species groups.

Germ shield color

Three of the genetically different groups, A, C1 and C2, form transparent hyaline to very light yellowish germ shields, e.g. *S. calospora*, *S. coralloidea* and *S. pellucida* (PLATES 4–6), whereas the genetic groups B1, B2 and B3 form distinctive yellow brown to dark brown pigmented germination shields, e.g. *S. heterogama*, *S. nigra* and *S. erythropus* (PLATES 7–9). The pigmentation of the germ shield is not correlated to the color of the spore walls; for example, the shield is brown-yellow to brown in white-spored *S. cerradensis* and *S. scutata* but hyaline to light yellow in *S. coralloidea* whose spores are dark colored. Some hyaline germ shields, when mounted on slides or stored in liquids of different media for several years, may somewhat darken and appear brownish: e.g., a germ shield of *S. coralloidea* isolated from the type at OSC that had been stored in lactophenol for 35 years had a partly darkened germ shield wall (FIG. 20). Likewise, the inner spore wall including the germ shield of *S. tricalypta* was darkened (FIG. 14), 25 years after being fixed on a slide in Ferrant mountant by Ferrer & Herrera (1981).

Germ shield shape

In planar view, germ shields are violin-shaped, oval to ovoid, coiled, circular, cardioid to reniform, or ellipsoid (PLATE 1). In principle three morphologically different germ shield types are observed (see TABLE 2, PLATES 1 & 4–9). Species of the genetic groups A have simple shields that are bi-lobed (FIGS. 1–3) — with the inner borders between the folds often forming a lyre, as in *S. calospora* — or (rarely) mono-lobed (FIG. 4) and coiled, as in *S. projecturata*. Such shields have, near the end of each lobe, one gti. In some specimens, simple bi-lobed shields appeared to have three or four lobes but these 'additional' lobes were only prolongations of the two initial lobes, or infolds of the same lobes that became apparent when the shield could not be observed in completely planar view (e.g., FIGS. 3, 18 for *S. nodosa*). Group B1 germ shields are also rather simple, bi-lobed and lyre-like (e.g. *S. heterogama* and *S. rubra*, FIGS. 45–47); in group B1 as well, further infolds of the two initial lobes may sometimes cause the shield to appear to have three or four lobes (e.g. *S. savannicola* in FIG. 48) even though group B1 germ shields have only (1–)2 gti. Species assigned to genetic groups C1 and C2 have a distinctly different germ shield morphology and a clear lyre shape is not visible. Multiple wavy lobes form an open network of many small compartments with up to 12 compartments with respective gti visible (FIG. 5 + PLATES 5–6). Finally, genetic groups B2 and B3 have highly complex-structured, compact shields with from 8–10 to 30 compartments, each with each one gti (FIGS. 6–9). The shield periphery of these species generally looks conspicuously dentate (e.g. FIGS. 8–9 + PLATES 7, 9).

Spore wall numbers

The outer wall (OW) in all *Scutellospora* spp. has three to four layers and the inner wall (IW) generally is 2-to-3-layered. Differences between the genetic groups are found in the number (0–2) of middle walls (TABLE 2). Genetic group C1 species lack any MW. Group A, B1, B2 and C2 species have one single- or bi-layered middle wall (MW; called GW1 by Morton 1995). Only, *S. erythropus* (group B3) forms two middle walls (MW1 and MW2).

Staining reaction of spore walls

Scutellospora spp. with one or two middle walls (i.e. generally all species in morphological groups A, B1, B2, B3 and C2) stain purple to deep purple in Melzer's reagent on the hyaline inner wall. In these groups, Melzer's staining reactions are less frequent on the outer wall and rare on the middle walls. Remarkably, all *Scutellospora* spp. lacking a middle wall (morphological group C1) have a staining reaction on the outer wall – similar to all species in *Gigaspora* but with a different staining intensity from yellow to yellow-orange to orange-red to red brown — but generally lack a staining reaction on the inner wall (TABLE 2).

Molecular phylogeny

The 18S and 25S rDNA-based clades generated by the two independent molecular phylogenetic reconstructions of the family *Gigasporaceae* were congruent and indicate polyphyly and paraphyly in the current classification (PLATES 2–3). Although the alignments show slight differences in tree topologies and species sequence composition, the major clades are identical. Strikingly, the clades obtained support our morphological analyses based mainly upon germination shield characteristics.

The 25S rDNA trees utilized a smaller number of *Scutellospora* species sequences than the 18S rDNA trees. Despite this, the fully resolved 25S rDNA trees comprised all six morphological groups based on examination of spores from all species described in this genus. For that reason we use PLATE 3 to show the molecular support for placing monophyletic groups into new families and genera.

The molecular reconstruction confirmed that *Gigaspora* derives from within *Scutellospora* and not the other way around as hypothesized by Morton (1990) and Bentivenga & Morton (1995). Here, *Scutellospora* sequences cluster in three A, B and C clades (PLATES 2–3). All three clades received high bootstrap values, regardless of tree-building method used (PLATE 3). The proposed new families are based on these three clades. The phylogenetic trees further show sub-clades, which we name at this stage A, B1, B2, B3, C1, C2 (PLATES 2–3). Although some sub-clades represent only one or few species sequences, they are further supported by our morphological analyses.

Group A (formed by *S. calospora* and related species) does not share the same most recent common ancestor either with the other two *Scutellospora* clades (B and C) or with *Gigaspora* in the 18S and 25S trees (PLATES 2–3), indicating polyphyly. However, although the 25S rDNA-generated distance tree implies paraphyly, it also fully supports monophyly for the groups used by us to propose new families. All Group A 25S sequences possess an indel (insertion-deletion sequence) shared only with the outgroup *Acaulosporaceae*

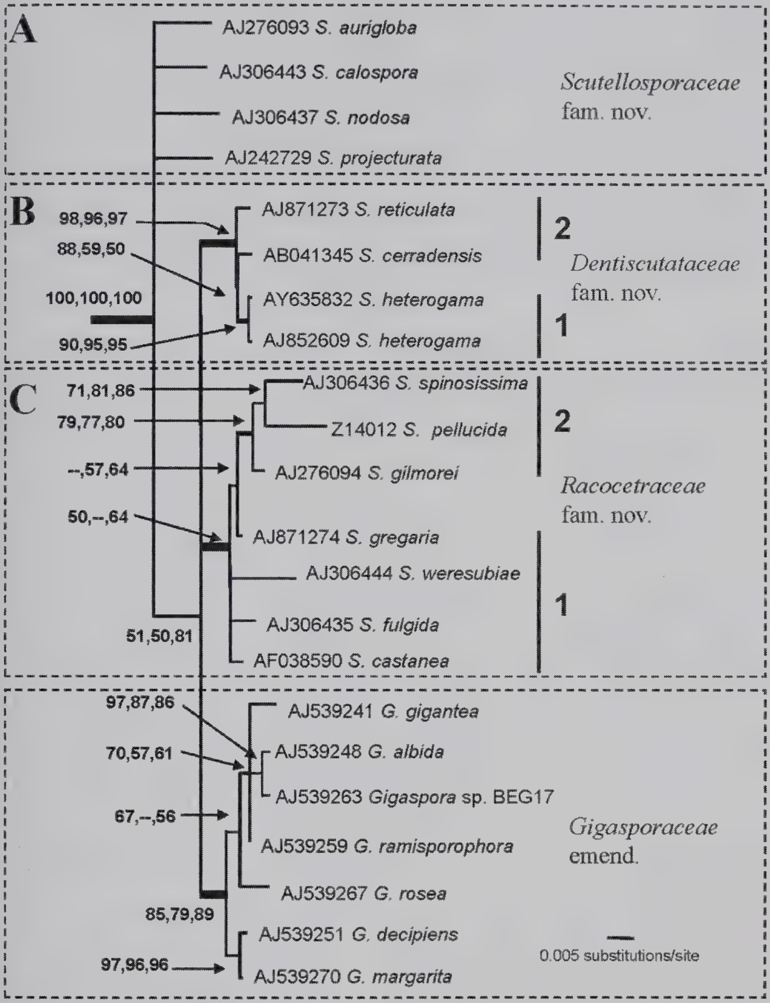

A
AJ276093 S. aurigloba
AJ306443 S. calospora
AJ306437 S. nodosa
AJ242729 S. projecturata
Scutellosporaceae fam. nov.
B
98,96,97
88,59,50
100,100,100
90,95,95
AJ871273 S. reticulata
AB041345 S. cerradensis
AY635832 S. heterogama
AJ852609 S. heterogama
2
1
Dentiscutataceae fam. nov.
C
71,81,86
79,77,80
--,57,64
50,--,64
51,50,81
AJ306436 S. spinosissima
Z14012 S. pellucida
AJ276094 S. gilmorei
AJ871274 S. gregaria
AJ306444 S. weresubiae
AJ306435 S. fulgida
AF038590 S. castanea
2
1
Racocetraceae fam. nov.
97,87,86
70,57,61
67,--,56
85,79,89
97,96,96
AJ539241 G. gigantea
AJ539248 G. albida
AJ539263 Gigaspora sp. BEG17
AJ539259 G. ramisporophora
AJ539267 G. rosea
AJ539251 G. decipiens
AJ539270 G. margarita
Gigasporaceae emend.
0.005 substitutions/site

Plate 2— fig. 10. Phylogenetic reconstruction of the family *Gigasporaceae* based on nearly complete 18S rDNA sequences. The tree was generated using Maximum Likelihood criteria with 1000 bootstrap replicates using the GTR substitution model (Lanave et al.1984) + I + G with the following parameters: a = 2.0779; b: 10.9922; c: 3.3253; d: 0.7967; e: 18.3736; Nucleotide frequencies: pi(A) = 0.2740; pi(C) = 0.1857; pi(G) = 0.2541; pi(T) = 0.2862; number of substitutions types 6, rates gamma, shape 0.6903 and proportion of invariable sites 0.6860. The tree was rooted using *Pacispora* (AJ619940, AJ619951) as outgroup. Bootstrap values for topologies obtained under distance (minimum evolution), maximum parsimony and maximum likelihood criteria are shown respectively. The thickest branch lines indicate the monophyletic groups used to erect new families; the second thickest branch lines show the genera. The three major *Scutellospora* clades are indicated by capital letters A, B and C, as well as the sub-clades B1, B2, C1 and C2. Note: sequences of sub-clade B3 unavailable for these trees.

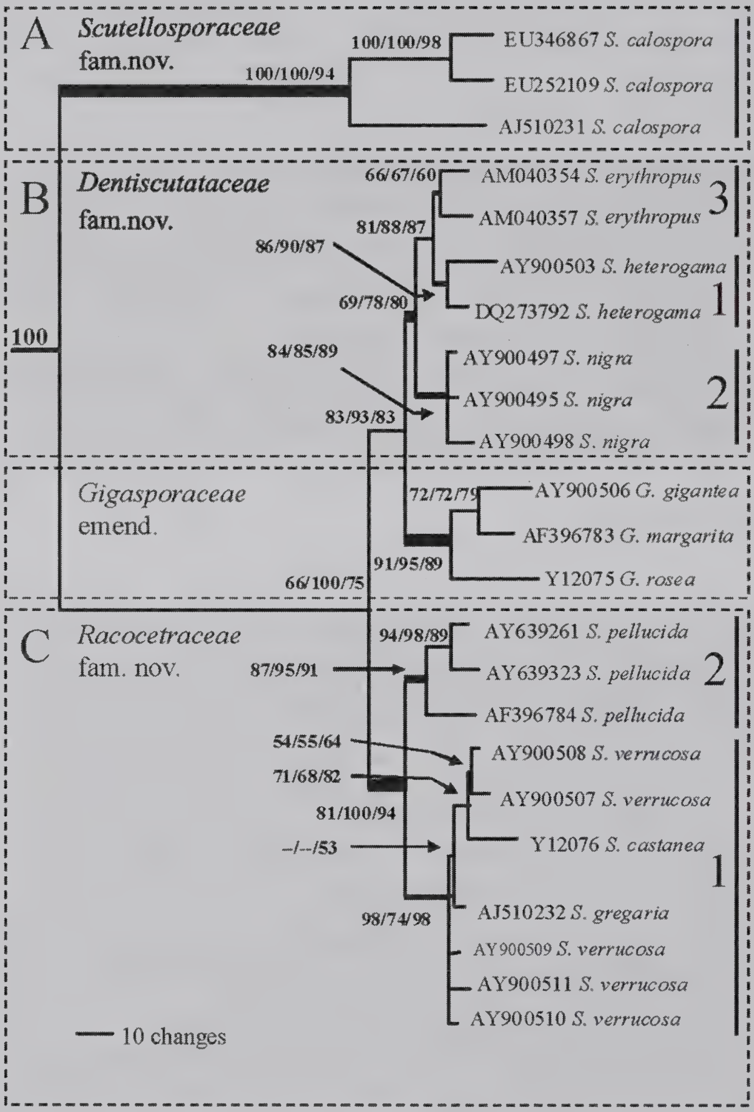

A
Scutellosporaceae
fam.nov.
100/100/98
100/100/94
EU346867 S. calospora
EU252109 S. calospora
AJ510231 S. calospora
B
Dentiscutataceae
fam.nov.
66/67/60
AM040354 S. erythropus
AM040357 S. erythropus
3
81/88/87
86/90/87
AY900503 S. heterogama
69/78/80
DQ273792 S. heterogama
1
100
84/85/89
AY900497 S. nigra
AY900495 S. nigra
2
83/93/83
AY900498 S. nigra
Gigasporaceae
emend.
72/72/79
AY900506 G. gigantea
AF396783 G. margarita
91/95/89
66/100/75
Y12075 G. rosea
C
Racocetraceae
fam. nov.
94/98/89
AY639261 S. pellucida
87/95/91
AY639323 S. pellucida
2
AF396784 S. pellucida
54/55/64
AY900508 S. verrucosa
71/68/82
AY900507 S. verrucosa
81/100/94
–/--/53
Y12076 S. castanea
1
98/74/98
AJ510232 S. gregaria
AY900509 S. verrucosa
AY900511 S. verrucosa
AY900510 S. verrucosa
10 changes

PLATE 3–FIG. 11. Phylogenetic reconstruction of the family *Gigasporaceae* based on partial 25S rDNA sequences. The tree was generated using Maximum Likelihood criteria with 1000 bootstrap replicates using the GTR substitution model (Lanave et al. 1984) + G substitution model with the following parameters: a = 0.4967; b: 7,3879; c: 2.4411; d: 0.8468; e: 15.7499; Nucleotide frequencies: pi(A) = 0.3057; pi(C) = 0.1423; pi(G) = 0.2535; pi(T) = 0.2985; Number of substitutions types 6, rates gamma, gamma distribution parameter alpha: 0.5688, proportion of invariable sites = 0. The tree was rooted with *Acaulospora* (AY900514, AJ510228) as outgroup. Bootstrap values for topologies obtained by Maximum Parsimony with gaps treated as missing character; Maximum (see alignment ALIGN_001257 deposited at EMBL database) indicating a common evolutionary event. The 18S-based tree could not fully resolve this clade, as it appears as a polytomy. Group B encompasses species sequences of three morphological groups based on our analyses. The trees strongly support separation of Group B2 from B1 and B3 (PLATE 3). Separation between B1 and B3 is less evident as both seem to descend from the same last common ancestor. Nevertheless, the remarkable morphological differences between species in B1 and B3 provide full support for our proposed taxonomic changes. Subgroups C1 and C2 within Group C are clearly separated in both 18S and 25S rRNA trees.

Our analyses clearly show that *Gigasporaceae* with its two old genera *Gigaspora* and *Scutellospora* do not reflect the evolutionary history of this group. The polyphyletic/paraphyletic nature of *Scutellospora* and the position of the *Gigaspora* clade within the *Scutellospora* clades solicitates the revision of the *Gigasporaceae* and supports the erection of three new families based on the clades A, B and C within the *Diversisporales*. The molecular phylogenetic reconstruction also gives some support for the erection of five new genera within the families erected from clades B and C (PLATE 3). Although the subgroups within clade B were represented by sequences of only one or two species in both trees, the morphological differences are conspicuous (TABLE 2): B1, represented by *S. heterogama*; B2, represented by *S. nigra,* and B3 represented by *S. erythropus*. Clade C clearly shows two well supported sub-clades: C1 and C2 (PLATE 3), with species belonging to each sub-clade possessing significant morphological spore differences (TABLE 2). Finally, the family *Gigasporaceae* remains with a single genus *Gigaspora.*

Re-organization of *Scutellospora* based on morphological and molecular analyses

Based on the morphological differences of germination shields and spore wall numbers (TABLE 2) and supported by the above phylogenetic analyses, (PLATES 2–3) we can attribute current *Scutellospora* species to three higher level (A, B, C) groups and six subgroups (A, B1, B2, B3, C1, C2); *Gigaspora* species form another distinct higher level group. Based on the higher groups, we first emend the *Gigasporaceae* and describe three new families in the *Diversisporales*. Further, from within *Scutellospora* we assign 10 species to genetic group A, 9 to Group C1, 5 to Group C2, 4 to Group B1, 7 (including one new species see below) to Group B2, and 1 to Group B3. We hereafter emend the genus description of

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Parsimony considering gaps as fifth state, and Maximum Likelihood criteria are shown respectively. The thickest branch lines designate monophyletic groups used to erect new families; the second thickest branch lines show the genera. The three major *Scutellospora* clades are indicated by capital letters A, B and C, as well as the sub-clades B1, B2, B3, C1 and C2.

Scutellospora, which corresponds to Group A, and describe five new genera corresponding to C1, C2, B1, B2 and B3. Following the International rules, we select a type species for each new genus from each genetically related group that was first described in literature. One exception was made for *S. heterogama* because of the particular taxonomic problems with this species (see below). Finally, we present identification keys to the families, genera and species with gigasporoid spore formation and list (TABLE 3–4) the morphological features obtained from all species in the former *Scutellospora* under the new generic headings.

Taxonomic problems encountered during study

While revising the *Gigasporaceae*, we encountered some species misidentifications and other problems noted below.

Isolates analysed and identified as *Scutellospora heterogama* by Franke & Morton (1994) and Jeffries et al. (2007) do not correspond to the *S. heterogama* type specimens deposited at FH (as *Endogone heterogama*). While *S. heterogama* sensu Franke & Morton (1994) and Jeffries et al. (2007) has a simple violin-shaped to oval germ shield, the germ shield of the FH type of *E. heterogama* is ellipsoid and has a dentate periphery and several gti. Also, the type spores are lighter in color (pale yellow-brown; Nicolson & Gerdemann 1968) than the red- to dark-brown spores of *S. heterogama* sensu Franke & Morton (1994) and Jeffries et al. (2007). For these reasons we cite below the type of *E. heterogama* in a new combination and describe *S. heterogama* sensu Franke & Morton and Jeffries et al. as a new species in a different genus.

Secondly, our examination of type materials deposited at OSC and FH revealed that *S. weresubiae* has only one inner wall, which does not stain in Melzer's, while the outer wall turns yellow to orange-yellow, a finding clearly different from the original description. We believe that Koske & Walker (1986) identified the thin innermost wall layer of the outer wall as a separating middle wall (Koske & Walker 1986).

Thirdly, *Scutellospora scutata* sensu Walker & Diederichs (1989) was described with three spore walls, while *S. scutata* sensu Silva et al. (2006b; based on INVAM reference accession BR243) has four spore walls. The germ shields in both have a dentated periphery in planar view but photographs of the germination shield in INVAM's *S. scutata* as published in Walker & Diederichs (1989) and here (FIG. 43, photographer F. Oehl) suggest two different species. We do not believe that the germ shield differences represent just an intra-species variation, but in the absence of complete information, we do not describe the INVAM specimen as a new species.

Next, we attributed *S. trirubiginopa* to Group B1 although it was not totally clear from the species description that the brown germination shield was indeed bi-lobed. Specimens were not available, and photographs of spores and the shield were not published. However, the description says that the germination shield is simple and that two germ tubes might arise from the shield.

For *S. crenulata* only a few spores were available to us, and the shields, hidden under the thick and conspicuously ornamented outer spore wall, were difficult both to detect and to isolate from the IW. Moreover, several infolds prevented us from determining the number and organization of the lobe(s) (FIGS. 19–20) and whether more than one gti was present.

Finally, we did not consider a sequence of *S. dipapillosa* (Z14013) in our molecular analyses as we have doubts about the correct species identification – it is likely that there was a confusion of *S. dipapillosa* with *S. heterogama* sensu Franke & Morton (1994) and Jeffries et al. (2007).

Molecular problems encountered during study

In the *Glomeromycota* the 18S rDNA genes possess low phylogenetical signal, and trees generated from 18S rDNA sequences did not fully resolve the ancestry of the clades B, C and *Gigaspora,* with Clade C receiving the lowest bootstrap values (PLATE 2), which point to a conflict in the position of clade C on 18S-based trees. On the other hand, the 25S rDNA-generated trees were fully resolved; the main clades used to erect new families received bootstrap values >66% among all tree-building methods used, and >80% for Maximum Likelihood criteria. Despite the lower number of available species sequences, groups obtained on the 25S rDNA trees are congruent with the germination shield-based morphological groups.

CLADE A – At one hand, the 18S rDNA based trees could not resolve the terminal nodes, which appear as a polytomy. On the other hand, the 25S rDNA trees were built using only sequences of a single species, *S. calospora.* Nonetheless, both tree topologies (PLATES 2–3) agreed with the placement of clade A (see also de Souza et al. 2005).

CLADE B – The 25S rDNA trees show support for the three proposed genera on this clade, but they were represented by sequences of only one species for each genus, while in the 18S rDNA based tree, there is no sequence of group B3, and differences between B1 and B2 are less resolved, due to the position of *S. cerradensis* sequences. The germination shield in *S. cerradensis* (FIG. 42; see also *S. hawaiiensis*, FIG. 41) differs to some extent from the typical dentate shields in *D. nigra* and all other *Dentiscutata* species (FIGS. 38–44), although it clearly resembles more the latter than the bi-lobed shields in *Fuscutata* species (PLATE 8). Further work is needed to resolve the relationships of *S. cerradensis* and *S. hawaiiensis.*

CLADE C – Clade C is well resolved on the 25S rDNA trees, although the subclade C1 terminal nodes appear as a polytomy and the *S. verrucosa* sequences appear non-monophyletic. We intentionally selected those *S. verrucosa* sequences to show this feature of AMF. The rDNA copies are polymorphic in the genome of all *Glomeromycota* species studied to date (see de Souza et al. 2004). Due to this intraspecific rDNA polymorphism, non-monophyly among rDNA copies obtained from a single species is common throughout the *Glomeromycota*. However, such polymorphism does not affect the resolution of the rDNA-based phylogeny.

Taxonomic revision of *Gigasporaceae*

Key to families and genera with spores formed on bulbous sporogenous cells (*Diversisporales*)

1a Spores with one spore wall; generally with germ warts on inner surface of the wall in mature spores .... Family 1: *Gigasporaceae (Gigaspora)*
1b Spores with outer spore wall and one to three inner walls; germination shield on innermost wall 2
2a Spores with a hyaline to subhyaline seldom light yellow germination shield 3
2b Spores with a yellow brown to brown germination wall
Family 4: *Dentiscutataceae* (3 genera) 4
3a Germ shield simple, generally (mono-) to bi-lobed, thus (1-)2 germ tube initiations (gti); spores with 3 walls .... Family 2: *Scutellosporaceae (Scutellospora)*
3b Germ shield multiple-lobed, 4 or more compartments with each one gti
Family 3: *Racocetraceae* (2 genera) 5
4a Germination shield simple, generally bi-lobed; spores with 3 walls ...... *Fuscutata*
4b Germination shield complex, >8 compartments, each with a gti; shield periphery generally dentate in planar view; spores with three or more walls 6
5a Spores with 2 walls .... *Racocetra*
5b Spores with 3 walls .... *Cetraspora*
6a Spores with 3 walls .... *Dentiscutata*
6b Spores with >3 walls .... *Quatunica*

Gigasporaceae J.B. Morton & Benny **emend. Sieverd., F.A. Souza & Oehl**

Emendation: Sporocarps are unknown. Spores formed singly in soil or rarely in roots. Spores are formed on bulbous sporogenous cells arising from subtending hyphae (sporophore) that differentiate from mycelia hyphae in soil. Spores with one spore wall consist of three layers: a unit, semi-persistent to persistent outer layer, a laminate middle layer and a thin inner germinal layer. The germinal layer has multiple, randomly or regularly organized germ warts. From one or sometimes several of the germ warts a germ tube arises during germination, penetrates directly the spore wall and generally branches in a short distance from the spore. Auxiliary cells formed in hyphal mycelium have spiny or nodulous elevations but not smooth round. Form arbuscular mycorrhiza; so far vesicles in roots unknown.

Type genus: *Gigaspora* Gerd. & Trappe emend. C. Walker & F.E. Sanders, Mycotaxon 27: 179. 1986.
Type species: *Gigaspora gigantea* (T.H. Nicolson & Gerd.) Gerd. & Trappe, Mycologia Memoir No. 5: 29. 1974.
Excluded genus: *Scutellospora*

Key to *Gigaspora* species

For the key we considered the original descriptions of the species. The synonymy of *G. ramisporophora* with *G. margarita* (Bentivenga & Morton 1995) is not accepted based on molecular (de Souza et al. 2004) and morphological (Spain et al. 1989) differences. *Gigaspora rosea* and *G. candida* are also treated as separate species. We exclude *G. tuberculata* from *Gigaspora* (see also Bentivenga & Morton 1995).

1a. Mean diameter of mature spores < 250 μm; spores rarely > 300 μm. 2
1b. Mean diameter of mature spores > 250 μm; spores generally > 300 μm. 3
2a Spores white when young 4
2b Spores white to cream, usually with a rose-pink tint; 230–300 μm in diam; sporogenous hyphae darker than the spore wall color . . . . *G. rosea*
3a Spores pearly white when young, 200–490 μm in diam 5
3b Spores generally pigmented already when young; 290–810 μm in diam; mature spores brilliant yellow-green, color associated with spore contents; spore contents turning bright red in alkaline solutions; laminae of spore wall not turning dark purple in Melzer's reagent; composite wall thickness generally < 10 μm . . . . *G. gigantea*
4a. Mature spores dull white with sporogenous hyphae similar in color with spore wall 6
4b. Spores (orange) white to white orange, 140–270 μm in diam . . . . *G. alboaurantiaca*
5a Spores with one sporogenous hyphae; 260–480 μm in diam mature spores pearly white to an opaque, creamy yellow color; composite wall thickness generally < 25 μm in diam. . . . . *G. margarita*
5b Spores with composite spore wall thickness generally > 25 μm, 200–500 μm in diam; mature spores yellow to brown 7
6a Spores with composite spore wall thickness generally < 8 μm, 200–300 μm in diam, average 250 μm, sporogenous cell dull white 30–50 μm diam . . . . *G. candida*
6b. Spore with composite spore wall thichness < 12 μm, 143–350 μm in diam, average 265 μm, sporogenous cell hyaline to yellow 24–50 μm diam . . . . . *G. albida*
7a Spores with composite spore wall thickness generally > 25 μm, 320–490 μm in diam; mature spores golden yellow to brown, with one sporogenous cell . . . . *G. decipiens*
7b. Spores as in 6a, subtending hypha forms one or more sporogenous cells one on top of other appearing as beads, spore formed on last cell; from any of the sporogenous cells another subtending hypha can emerge and may or may not form another sporogenous cell from which another spore forms . . . . *G. ramisporophora*

Scutellosporaceae Sieverd., F.A. Souza & Oehl, **fam. nov.**

MB 511945

> *Sporae terminaliter efformatae anguste adiacetae ad cellulas sporogeneas; cum tunicis tribus; scutellum germinale coniunctum ad tunicam interiorem, viola-forme vel ovale vel cardioforme, hyalinum ad alboflavum, cum 1–2 lobis et depressionibus germationis; formans structuras mycorrhizarum arbuscularum.*

Key characters: Sporocarps are unknown. Spores generally singly formed on bulbous sporogenous cells that are formed terminally on a subtending hypha that arises from mycelia hyphae in soil. Spores have 3 walls, an outer, a middle and an inner, germinal wall. Outer wall with 3 or several layers, middle wall with 1–2 layers, and inner wall with 2 or several layers. A germination shield is formed on the outer surface or between the outer and the subsequent layer of the inner wall. Germination shield is transparent, or hyaline to subhyaline, seldom light yellow, generally bi-lobed, rarely mono-lobed; often violin-shaped or oval to ovoid, rarely cardioid, circular or coiled; only a few folds cover the shield surface where in general two germ tube initiations (gti) are formed. Generally from one gti, seldom from both gti, a germ tube arises and penetrates the outer spore walls. Subtending hyphae form one to several septa in some distance to the sporogenous cells. Auxiliary cells in the hyphal mycelium are, as far as known, knobby without spines on the surface. Forming typical arbuscular mycorrhizae; vesicle formation in roots is so far unknown.

Type genus: *Scutellospora* C. Walker & F.E. Sanders emend. Oehl et al.

Scutellospora C. Walker & F.E. Sanders. **emend. Oehl, F.A. Souza & Sieverd.**

Emendation: Sporocarps unknown. Spores formed on sporogenous cells that form terminally on a hypha which arises from mycelia hyphae in soil. Outer spore wall generally is three-layered and continuous with the wall of the sporogenous cell. Outer layer of the outer spore wall generally rigid, second layer laminate and third layer thin, often membranous, tightly adherent to the laminate layer and thus, often difficult to observe. Pore between the spore and sporogenous cell is narrow and usually closed by a plug formed by spore wall material. Two hyaline walls ('mw' and 'iw') form de novo during spore formation and have 1–2 and 2–3 layers, respectively. The iw is two to three-layered forming a germination shield on its outer surface or between the outer and the subsequent layer of iw. Germination shield is transparent, or hyaline to subhyaline, seldom light yellow, bi- to mono-lobed; often violin-shaped to oval to ovoid to more rarely cardioids or coiled and then, either circular or apparently broad ellipsoid to irregular; only a few folds cover the shield surface where 1–2 rounded germ tube initiations ('gti', about 2–4 μm in diam) are visible from where the germ tubes arise which penetrate the outer spore wall layers. Mycelia hyphae form one to several septa in some distance to the sporogenous cells. Auxiliary cells in the hyphal mycelium, as far as known, are knobby without spines on the surface. Forming typical arbuscular mycorrhizae, vesicle formation in roots so far unknown.

TYPE SPECIES: *Scutellospora calospora* (T.H. Nicolson & Gerd.) C. Walker & F.E. Sanders

Key to *Scutellospora* species

1a Spores without ornamentation on outer wall.................................2
1b Spores with ornamentation on outer wall 3

2a Spores light colored: subhyaline, pink, creamy, straw to greenish or brownish yellow 4
2b Spores yellow brown to black.................................5

3a Spores with one homogenous ornamentation on spore surface 6
3b Spores with two-type ornamentation on spore surface 7

4a Spores subhyaline to creamy to pale straw to greenish yellow..................8
4b Spores dark yellow to golden yellow to brown yellow 9

5a Spores yellow brown to orange-brown, 160–360 μm in diam, outer and innermost wall strongly staining in Melzer's reagent ....*S. arenicola*
5b Spores dark brown to black, 300–460 μm in diam .... *S. tricalypta*

6a Spores hyaline to pale yellow, 160–270 μm in diam; with knobs 3.5–6.5 μm high and 7.0–10.5 μm wide at base .... *S. nodosa*
6b Spores golden yellow to ochraeous to sienna, 100–180 μm in diam; with 2.0–4.0 μm long protuberances formed by the structural, laminated layer of the outer wall .... *S. projecturata*

7a Spores with two-type ornamentation on spore surface; spores pale orange brown to dark orange brown, 130–180 μm in diam; with small conical warts and additional blunt, bacilliform larger projections on the spore surface .... *S. dipapillosa*
7b Spores with warted projections having central secondary projections in the tip; spores cream to yellow, 100–170 μm in diam.....................*S. crenulata*

8a Spores subhyaline to pale straw to pale greenish-yellow, (100–)150–300(–500) μm in diam, generally ellipsoid to oblang, with bi-layered middle wall . . .*S. calospora*
8b Spores yellow to greenish-yellow; 140–240 μm in diam, generally globose to subglobose, with one layered middle wall......................*S. dipurpurescens*

9a Spores golden yellow to dull yellow, (130–)200–420(–520) μm .... *S. aurigloba*
9b Spores dark yellow to brown yellow (to yellow brown), 105–150 μm, outer spore wall strongly expanding in lactic acid based mountants........*S. pernambucana*

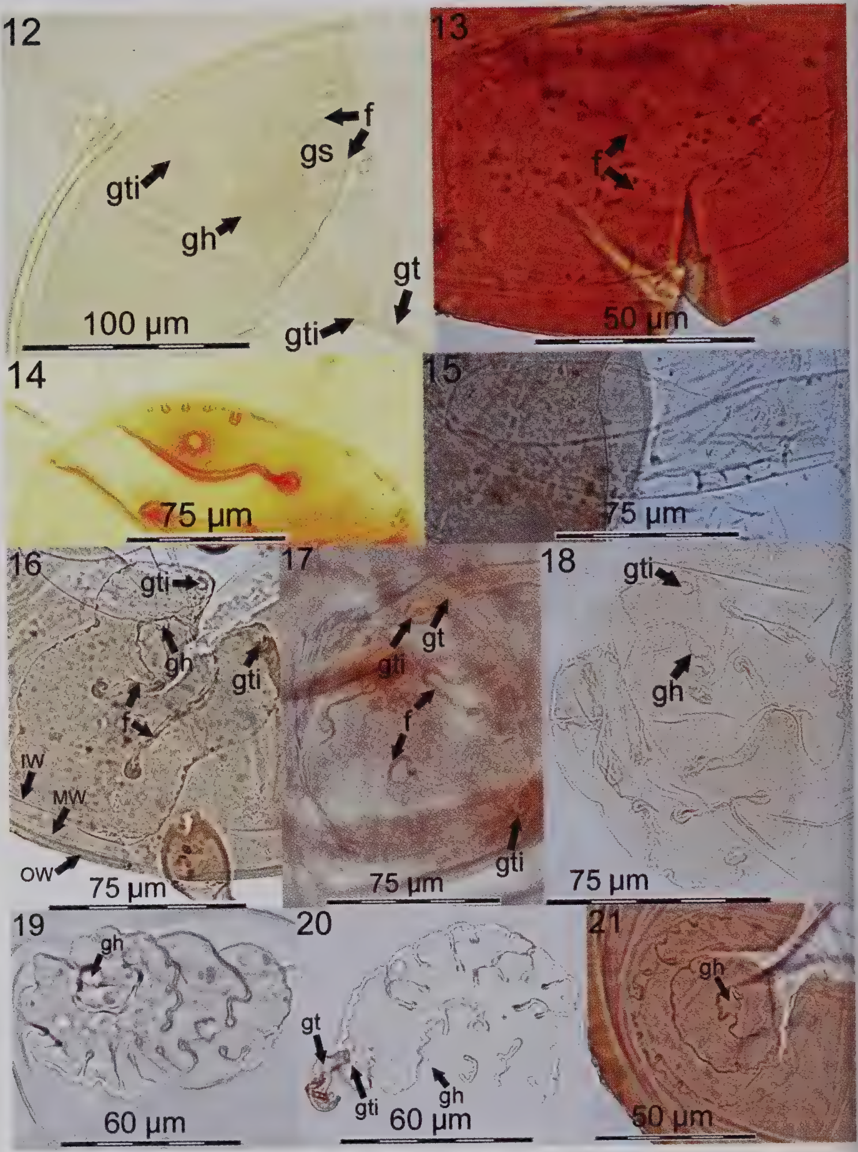
12
f
gs
gti
gh
gt
gti
100 µm
13
f
50 µm
14
75 µm
15
75 µm
16
gti
gh
gti
f
iw
mw
ow
75 µm
17
gt
gti
f
gti
75 µm
18
gti
gh
75 µm
19
gh
60 µm
20
gt
gti
gh
60 µm
21
gh
50 µm

PLATE 4—Typical simple, hyaline to subhyaline, violin-shaped to oval, to rarely cardioid, circular, oblong or irregular germination shields in *Scutellospora* spores. Spores have one outer (OW), one middle (MW) and one inner (IW) spore wall. Generally, shields have two compartments (lobes) with one germ tube initiation (gti) per lobe from where the germ tubes (gt) may arise (germination visible in FIG. 12). Rarely shields are mono-lobed (FIGS. 19–21). Shield and inner wall in *S. tricalypta* darkened during 25 years mounted in Ferrant medium (FIG. 14).

Scutellospora arenicola Koske & Halvorson,
Mycologia 81: 927. 1990 ['1989']. (FIG. 15)

Scutellospora aurigloba (I.R. Hall) C. Walker & F.E. Sanders.,
Mycotaxon 27: 180. 1986; emend. C. Walker & I.R. Hall,
Mycol. Res. 95: 400. 1991. (FIG. 17)
BASIONYM: *Gigaspora aurigloba* I.R. Hall, Trans. Brit. Mycol. Soc. 68: 351. 1977.

Scutellospora calospora (T.H. Nicolson & Gerd.) C. Walker & F.E. Sanders,
Mycotaxon 27: 180. 1986. (FIG. 12)
BASIONYM: *Endogone calospora* T.H. Nicolson & Gerd., Mycologia 60: 322. 1968.
≡ *Gigaspora calospora* (T.H. Nicolson & Gerd.) Gerd. & Trappe,
Mycologia Memoir No. 5: 28. 1974.

Scutellospora crenulata R.A. Herrera, Cuenca & C. Walker,
Can. J. Bot. 79: 674. 2001. (FIGS. 19–20)

Scutellospora dipapillosa (C. Walker & Koske) C. Walker & F.E. Sanders,
Mycotaxon 27, 181. 1986. (FIG. 13)
BASIONYM: *Gigaspora dipapillosa* C. Walker & Koske, Mycologia 77: 709. 1985.

Scutellospora dipurpurescens J.B. Morton & Koske,
Mycologia 80: 520. 1988. (FIG. 16)

Scutellospora nodosa Błaszk., Mycologia 83, 537. 1991. (FIG. 18)

Scutellospora pernambucana Oehl, D.K. Silva, N. Freitas, L.C. Maia,
Mycotaxon 106: 363. 2008. (FIG. 21)

Scutellospora projecturata Kramad. & C. Walker, Annals Bot. 86: 22. 2000.

Scutellospora tricalypta (R.A. Herrera & Ferrer) C. Walker & F.E. Sanders,
Mycotaxon 27: 180. 1986. (FIG. 14)
BASIONYM: *Gigaspora tricalypta* R.A. Herrera & Ferrer, Rev. Jard. Bot. Nacional, Habana. 1: 49. 1981 ['1980'].

Racocetraceae Oehl, Sieverd. & F.A. Souza, **fam. nov.**
MB 511946

Sporae terminaliter efformatae anguste adiacetae ad cellulas sporogeneas; scutellum germinale coniunctum ad tunicam interiorem, hyalinum subhyalinum ad alboflavum, undulo-lobatum cum 4–12 lobis et 4–12 depressionibus circularibus germinationis; formans structuras mycorrhizarum arbuscularum.

FIG. 12. Type species *S. calospora* (germination visible). FIG. 13. *S. dipapillosa* FIG. 14. *S. tricalypta* (25-year old spores in Ferrant medium). FIG. 15. *S. arenicola*. FIG. 16. *S. dipurpurescens*. FIG. 17. *S. aurigloba*. FIG. 18. *S. nodosa*. FIGS. 19–20. *S. crenulata* (monolobed). FIG. 21. *S. pernambucana* (monolobed).

Key characters: Spores formed singly in soils and rarely in roots formed on bulbous sporogenous cells which are formed terminally on a subtending hypha that arises from mycelia hyphae. Spores with two to three walls: an outer spore wall, either no middle wall or one middle wall, and an inner germinal wall. Each wall if present has one, two or several layers. A germination shield arises on the outer surface or beneath a thin outer layer of the inner wall; germination shield is hyaline to subhyaline seldom light yellow, generally oval to ellipsoid or subglobose, with several (4–12) conspicuously lobed, wave-like projections forming the outer surface of the shield; folds separate the lobes in compartments on the shield, and each compartment may have a germ tube initiation (gti). From one or rarely two gti a germ tube may arise and penetrate the middle and the outer spore wall. In the substending hypha of the sporogenous cell, often several septae are formed in some distance from pore. Auxiliary cells in the hyphal mycelium as far as they are known knobby without spines on the surface. Forming typical arbuscular mycorrhizae; vesicle formation in roots unknown.

Type genus: *Racocetra* Oehl et al.

Other genus: *Cetraspora*

Racocetra **Oehl,** F.A. Souza & Sieverd., **gen. nov.**

MB 511947

Sporae terminaliter efformatae anguste adiacetae ad cellulas sporogeneas; cum tunicis duabus; scutellum germinale coniunctum ad tunicam interiorem, hyalinum ad alboflavum, undulo-lobatum, 4–12 lobis et 4–12 depressionibus germinatione; formans structuras mycorrhizarum arbuscularum.

Etymology: from the Greek: (ρακος, racos = cloth, lobe), and from the Latin: cetra (light shield), referring to the wavy-lobed surface of the germination shield in planar view.

Key characters: Spores formed singly in soil and rarely in roots, on bulbous sporogenous cells that arise terminally on mycelia hyphae. Outer spore wall is generally three-layered and continuous with the wall of the sporogenous cell. Outer layer of the outer spore wall generally semi-persistent to persistent, rigid; second layer laminate; third layer thin, often membranous, tightly adherent to the laminate layer and thus, often difficult to observe. Pore between spore and sporogenous cell is narrow and usually closed by a plug formed by spore wall material. A single inner wall forms de novo during spore formation and has two to three layers. A germination shield arises on the outer surface or beneath a thin outer layer of the inner wall; germination shield is hyaline to subhyaline seldom light yellow, generally oval to ellipsoid or subglobose, with several (4–12) wave-like lobed projections forming the outer surface of the shield; folds separate the lobes on the shield, and each lobe may have a germ tube initiation

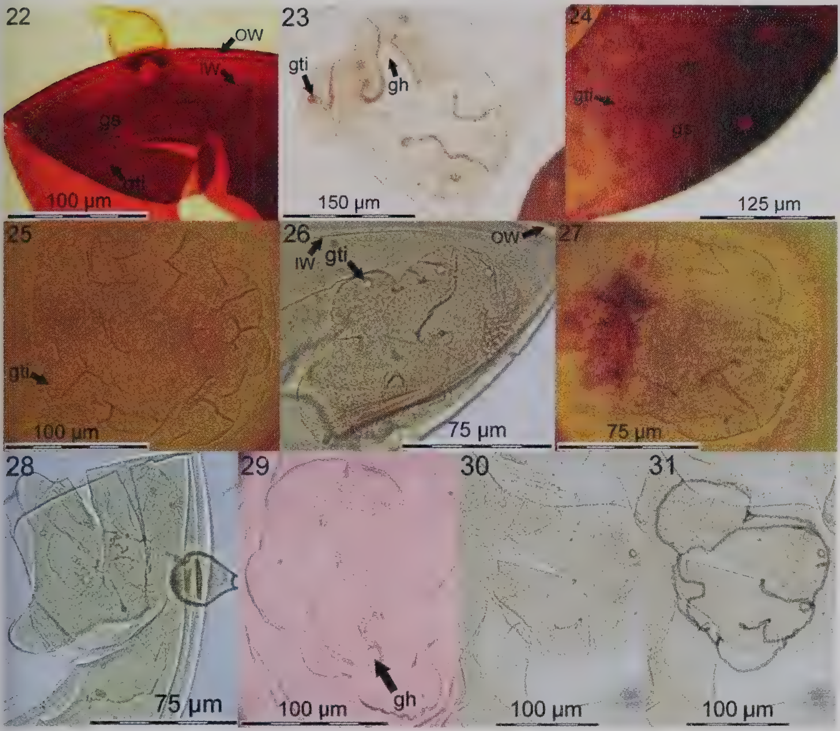

PLATE 5—*Racocetra* germination shields (gs) have multiple compartments that give a multiple-lobed, wavy shield appearance. *Racocetra* spores have one outer (OW) and one inner (IW) spore wall. Generally one germ hole (gh) present with one germ tube initiation (gti) visible on each of the multiple lobes.

FIG. 22–23. Type species *R. coralloidea*. FIG. 23. Germ shield wall in the type specimen partly darkened after more than 30 years of storage in lactophenol. FIG. 24. *R. gregaria*. FIG. 25. *R. castanea*. FIG. 26. *R. persica*. FIG. 27. *R. verrucosa*. FIGS. 28–29. *R. fulgida*. FIG. 29. Shield in a newly developed spore; gti's not yet formed. FIGS. 30–31. *R. weresubiae* shield not completely visible in planar view and thus overlapping itself; slightly deformed through spore crushing; FIG. 31. Shield wall amplified using Adobe® Photoshop 9.0.

(about 2–5 µm in diam) from where the germ tubes arise and penetrate the outer wall. In the subtending hypha of the sporogenous cell one to several septa formed in some distance to the sporogenous cells. Auxiliary cells in the hyphal mycelium (as far as they are known) knobby without spines on the surface. Forming typical arbuscular mycorrhizae; vesicle formation in roots is so far unknown.

TYPE SPECIES: *Racocetra coralloidea* (Trappe, Gerd. & I. Ho) Oehl et al.

Key to *Racocetra* species

1a Spores without ornamentation on outer wall 2

1b Spores with ornamentation on outer wall 3

2a Spores light colored 4

2b Spores creamy-brown to brown-sienna, 170–370 µm in diam . . . . *R. castanea*

3a Surface ornamentation with spines or warts generally < 2.5 µm in diam 5

3b Surface ornamentation with projections generally > 2.5 µm in diam 6

4a Spores hyaline to pale straw to pale yellowish-cream, 160–250 µm in diam . . . . *R. fulgida*

4b Spores pale to dark pink, 120–170 × 130–420 µm in diam; outer wall staining yellow to yellow orange in Melzer's reagent . . . . (*R. alborosea*)/*R. weresubiae*

5a Spore surface with fine spines; spores pinkish-orange to brownish orange, 270–390 µm in diam. . . . . *R. persica*

5b Spore surface with crowded rounded warts; spores pale straw to yellow to light orange brown, 220–480 µm in diam. . . . . *R. verrucosa*

6a Spores red brown to dark brown with rounded projections on surface 7

6b Spores dark brown, 300–460 µm in diam; with coralloidic warts . . . . . . *R. coralloidea*

7a Spores red brown to dark brown, 250–450 µm in diam; with rounded dome-shaped warts. . . . . *R. gregaria*

7b Spores brown to dark brown; 90–180 µm in diam; warts on top with central depressions . . . . *R. minuta*

Racocetra alborosea (Ferrer & R.A. Herrera) Oehl, F.A. Souza & Sieverd., **comb. nov.**

MB 511950

Basionym: *Gigaspora alborosea* Ferrer & R.A. Herrera, Rev. Jardin Bot. Nacional, Habana. 1: 55. 1981 ['1980'].

≡ *Scutellospora alborosea* (Ferrer & R.A. Herrera) C. Walker & F.E. Sanders, Mycotaxon 27: 180. 1986.

Racocetra castanea (C. Walker) Oehl, F.A. Souza & Sieverd., **comb. nov.**

MB 511952 (fig. 25)

Basionym: *Scutellospora castanea* C. Walker, Cryptogamie Mycologie 14: 280. 1993.

Racocetra coralloidea (Trappe, Gerd. & I. Ho) Oehl, F.A. Souza & Sieverd., **comb. nov.** (figs. 22–23)

MB 511948

Basionym: *Gigaspora coralloidea* Trappe, Gerd. & I. Ho, Mycologia Memoir No. 5: 30. 1974.

≡ *Scutellospora coralloidea* (Trappe, Gerd. & I. Ho) C. Walker & F.E. Sanders, Mycotaxon 27: 181. 1986.

Racocetra fulgida (Koske & C. Walker) Oehl, F.A. Souza & Sieverd., **comb. nov.** (figs. 28–29)

MB 511955

Basionym: *Scutellospora fulgida* Koske & C. Walker, Mycotaxon 27: 221. 1986.

Racocetra gregaria (N.C. Schenck & T.H. Nicolson) Oehl, F.A. Souza & Sieverd., **comb. nov.** (FIG. 24)
MB 511949
BASIONYM: *Gigaspora gregaria* N.C. Schenck & T.H. Nicolson, Mycologia 71: 185. 1979.
≡ *Scutellospora gregaria* (N.C. Schenck & T.H. Nicolson) C. Walker & F.E. Sanders, Mycotaxon 27: 181. 1986.

Racocetra minuta (Ferrer & R.A. Herrera) Oehl, F.A. Souza & Sieverd., **comb. nov.**
MB 511951
BASIONYM: *Gigaspora minuta* Ferrer & R.A. Herrera, Rev. Jardin Bot. Nacional, Habana. 1: 53. 1981 ['1980'].
≡ *Scutellospora minuta* (Ferrer & R.A. Herrera) C. Walker & F.E. Sanders, Mycotaxon 27: 180. 1986.

Racocetra persica (Koske & C. Walker) Oehl, F.A. Souza & Sieverd., **comb. nov.**
MB 511953 (FIG. 26)
BASIONYM: *Gigaspora persica* Koske & C. Walker, Mycologia 77: 708. 1985.
≡ *Scutellospora persica* (Koske & C. Walker) C. Walker & F.E. Sanders, Mycotaxon 27:181. 1986.

Racocetra verrucosa (Koske & C. Walker) Oehl, F.A. Souza & Sieverd., **comb. nov.**
MB 511954 (FIG. 27)
BASIONYM: *Gigaspora verrucosa* Koske & C. Walker, Mycologia 77: 705. 1985.
≡ *Scutellospora verrucosa* (Koske & C. Walker) C. Walker & F.E. Sanders, Mycotaxon 27: 181. 1986.

Racocetra weresubiae (Koske & C. Walker) Oehl, F.A. Souza & Sieverd., **comb. nov.**
MB 511956 (FIGS. 30–31)
BASIONYM: *Scutellospora weresubiae* Koske & C. Walker, Mycotaxon 27: 224. 1986.

Cetraspora Oehl, F.A. Souza & Sieverd., **gen. nov.**
MB 511957

Sporae terminaliter efformatae anguste adiacetae ad cellulas sporogeneas; cum tunicis tribus: scutellum germinale coniunctum ad tunicam interiorem, hyalinum ad alboflavum, undulo-lobatum, cum 4–12 lobis et 4–12 depressionibus germinatione; formans structuras mycorrhizarum arbuscularum.

ETYMOLOGY: from the Latin: *cetra* (= light shield) and spora (= spore), referring to the light colored germination shield which often is difficult to observe, as in *C. gilmorei* and especially in *C. pellucida*.

KEY CHARACTERS — Spores formed singly in soil and rarely in roots on bulbous sporogenous cells that arise terminally on a subtending hypha which is connected to mycelium. Outer spore wall generally is three-layered and continuous with the wall of the sporogenous cell. Outer layer of the outer spore wall generally semi-persistent to persistent, rigid; second layer laminate; third layer thin, often membranous, tightly adherent to the laminate layer and thus, often difficult to observe. Pore between spore and sporogenous cell is narrow and usually closed by a plug formed by spore wall material. Two hyaline walls ('middle wall' and 'inner wall') form de novo during spore formation and have 1–2 and 2–3 layers, respectively. A germination shield arises on the outer surface of the inner wall or beneath a thin outer layer of the innermost wall; germination shield is hyaline to subhyaline seldom light yellow, generally oval to ellipsoid or subglobose, with several (4–12) wave-like lobed projections forming the outer surface of the shield; large folds separate the lobes on the shield, and each lobe may have an germ tube initiation (about 2–5 µm in diam) from where the germ tubes arise and penetrate the overlaying spore walls. Subtending hyphae form one to several septa in some distance to the sporogenous cells. Auxiliary cells in the hyphal mycelium as far as they are known knobby without spines on the surface. Forming typical arbuscular mycorrhizae; vesicle formation in roots is unknown.

TYPE SPECIES: *Cetraspora gilmorei* (Trappe & Gerd.) Oehl et al.

Key to *Cetraspora* species

1a Spores without ornamentation on outer wall 2
1b Spores with ornamentation on outer wall 3

2a Spores hyaline to white 4
2b Spores apricot yellow to yellow brown, 140–240 µm in diam .... *S. armeniaca*

3a Spores with a fine dense spiny ornamentation on outer spore wall; spores ochraeous to fulvous or rust, 130–230 µm in diam .... *C. spinosissima*
3b Spores ornamentated with finger-print-like processes in planar view; spores ochraeous yellow with a pinkish tint, 110–190 µm in diam .... *C. striata*

4a Spores brilliant hyaline, white to rarely pale grey, generally globose to subglobose; (60–)120–250(–420) µm in diam; sporogenous cell a hyaline to subhyaline; germination shield generally not seen .... *C. pellucida*
4b Spores hyaline, becoming creamy under storage in formalin; globose to subglobose to ellipsoid; 200–320 µm in diam; sporogenous cell brown; germination shield generally easy to observe .... *C. gilmorei*

Cetraspora armeniaca (Błaszk.) Oehl, F.A. Souza & Sieverd., **comb. nov.** (FIG. 35)
MB 511961
BASIONYM: *Scutellospora armeniaca* Błaszk., Mycologia 84: 939. 1993.

Cetraspora gilmorei (Trappe & Gerd.) Oehl, F.A. Souza & Sieverd., **comb. nov.**
MB 511958 (FIGS. 32–33)
BASIONYM: *Gigaspora gilmorei* Trappe & Gerd., Mycologia Memoir No. 5: 27. 1974.
≡ *Scutellospora gilmorei* (Trappe & Gerd.) C. Walker & F.E. Sanders, Mycotaxon 27: 181. 1986.

Cetraspora pellucida (T.H. Nicolson & N.C. Schenck) Oehl, F.A. Souza & Sieverd., **comb. nov.** (FIG. 34)
MB 511959

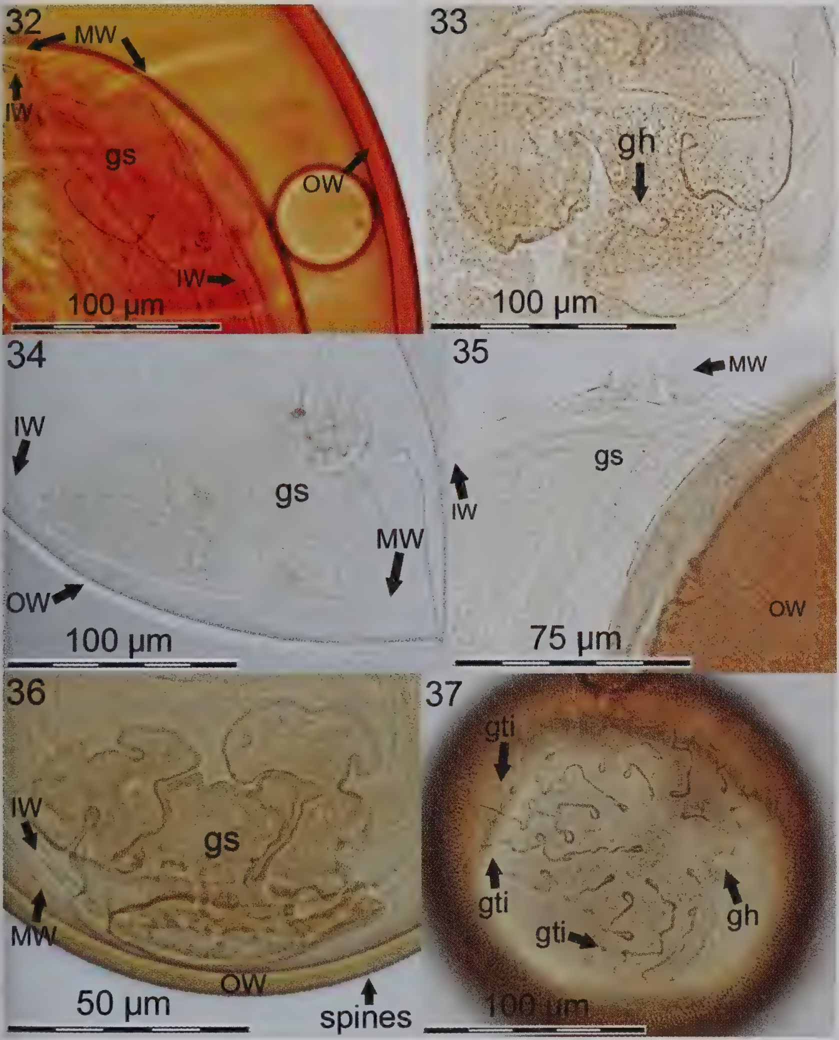
32
MW
IW
gs
OW
IW
100 µm
33
gh
100 µm
34
IW
gs
MW
OW
100 µm
35
MW
gs
IW
OW
75 µm
36
IW
gs
MW
OW
50 µm
spines
37
gti
gti
gti
gh
100 µm

PLATE 6—Multiple-lobed, wavy germination shield (gs) form in *Cetraspora* spores; spores with one outer (OW), one middle (MW) and one inner (IW) spore wall. On each of the lobes (compartments) a germ tube initiation (gti) might be formed from where the germ tubes arise. Shields and gti are generally light or transparent and less obvious than in *Racocetra*.

FIG. 32–33. Type specimen of *C. gilmorei*. Spore walls and shield have darkened after > 30 years stored in lactophenol. FIG. 34. *C. pellucida*. FIG. 35. *C. armeniaca*. FIGS. 36–37. *C. spinosissima*.

BASIONYM: *Gigaspora pellucida* T.H. Nicolson & N.C. Schenck, Mycologia 71: 189. 1979.

≡ *Scutellospora pellucida* (T.H. Nicolson & N.C. Schenck) C. Walker & F.E. Sanders, Mycotaxon 27: 181. 1986.

Cetraspora spinosissima (C. Walker & Cuenca) Oehl, F.A. Souza & Sieverd., **comb. nov.** (FIGS. 36–37)
MB 511960

BASIONYM: *Scutellospora spinosissima* C. Walker & Cuenca, Annals Bot. 82: 723. 1998.

Cetraspora striata (Cuenca & R.A. Herrera) Oehl, F.A. Souza & Sieverd., **comb. nov.**
MB 512598

BASIONYM: *Scutellospora striata* Cuenca & R.A. Herrera, Mycotaxon 105: 81. 2008.

Dentiscutataceae F.A. Souza, Oehl & Sieverd., **fam. nov.**
MB 511962

Sporae terminaliter efformatae anguste adiacetae ad cellulas sporogeneas; cum tunicis tribus vel quartuoribus; scutellum germinale coniunctum ad tunicam interiorem, flavo-brunneum ad brunneum, viola-forme vel ovale vel cardioforme vel ellipsoideum. Formans structuras mycorrhizarum arbuscularum.

KEY CHARACTERS: Sporocarps are unknown. Spores formed singly on bulbous sporogenous cells which are formed terminally on a subtending hypha that arise from mycelia hyphae. Outer spore wall three- to four to rarely five-layered. Spores have 3–4 walls, an outer spore wall with several layers, one to several middle walls and an inner wall each of two or more layers. Germination shield generally formed on the outer surface of the innermost wall or beneath a thin outer layer of the inner wall, yellow-brown to brown, violin-shaped to oval to ovoid to heart-shaped to reniforme to ellipsoid, consisting of two lobe-like compartments or up to 30 small compartments. Lobes and compartments are separated by folds and generally have each one germ tube initiations; from one to a few gti a germ tube may arise penetrating the other walls. Subtending hypha forms one to several septa in some distance to the sporogenous cells. Auxiliary cells in the mycelium hyphae as far as they are known knobby without spines on the surface. Forming typical arbuscular mycorrhizae, vesicle formation in roots unknown.

TYPE GENUS: *Dentiscutata* Sieverd. et al.

OTHER GENERA: *Fuscutata, Quatunica*

Dentiscutata Sieverd., F.A. Souza & Oehl, **gen. nov.**
MB 511968

Sporae singulatim terminaliter efformatae anguste adiacetae ad cellulas sporogeneas; cum tunicis tribus; scutellum germinale coniunctum ad tunicam interiorem, flavo-brunneum ad brunneum; cum 8–30 compartimentibus et depressionibus germinationis; formans structuras mycorrhizarum arbuscularum.

ETYMOLOGY: From the Latin denti(culata) (= dentate), and scutata (= 'shielded'), referring to the dentate form of the periphery of the brown germination shield.

KEY CHARACTERS: Sporocarps are unknown. Spores singly formed on bulbous sporogenous cells that are formed terminally on subtending hypha that arises from mycelia hyphae. Outer spore wall is three- to five-layered and continuous with the wall of the sporogenous cell. Pore between the spore and sporogenous cell is narrow and usually closed by a plug formed by outer spore wall material. A hyaline middle wall and a hyaline inner wall form de novo during spore formation; middle wall one- to bilayered; inner wall two to three-layered. Germination shield generally arising on the outer surface of the innerwall or beneath a thin outer layer of the inner wall, yellow-brown to brown, generally ellipsoid (to oval), or rarely reniforme to cardioforme, usually with many (8–30) large folds separating the shield into 8–30 'small compartments'; each small compartment generally with one circular germ tube initiation; usually from one or a few gti germ tubes may arise and penetrate the middle wall and the outer wall; the periphery of the germination shield generally appears dentate in planar view. Septa often formed in subtending hypha in some distance to the sporogenous cells. Auxiliary cells formed in hyphal mycelium as far as they are known knobby without spines on the surface. Forming typical arbuscular mycorrhizae, vesicle formation in roots so far unknown.

TYPE SPECIES: *Dentiscutata nigra* (J.F. Redhead) Sieverd. et al.

Key to *Dentiscutata* species

1a Spores without ornamentation on outer wall.................................2
1b Spores with ornamentation on outer wall 3

2a Spores hyaline, white to light olive, 350–750 μm in diam
.........................*D. scutata* (sensu Walker & Diederichs 1989)
2b Spores pale orange brown to red brown, 200–300 μm in diam; outer wall not
staining in Melzer's reagent; second middle wall layer fracturing with a series
of rectangular and V-shaped notches......................... *D. hawaiiensis*

3a Spores with a single ornamentation on outer spore wall 4
3b Spores with double ornamentation on outer spore wall.........................5

4a Spores hyaline to white, globose to ovoid, 170–370 μm in diam; with spiny
papillae ornamentation .... *D. cerradensis*
4b Spore with papillae surface ornamentation on outer wall; Spores light brown,
globose to ellipsoid, 150–260 μm in diam...................... *D. heterogama*

5a Spores with double ornamentation on the outer spore surface.................. 6
5a Spores with each one papillae ornamentation both on outer and inner surface
of the outer wall; yellow-brown to brown, (120–)260–450(–500) μm
in diam ....*D. biornata*

6a Spores orange brown to dark red brown, 200–470 μm in diam; having spines in the
depressions of a reticulum....................................*D. reticulata*
6b Spores dark brown to black, 290–500(–1050); with rounded pits and a sinuous
secondary ornamentation below ....*D. nigra*

Dentiscutata biornata (Spain, Sieverd. & S. Toro) Sieverd., F.A. Souza & Oehl, **comb. nov.** (FIG. 40)
MB 511971
BASIONYM: *Scutellospora biornata* Spain, Sieverd & S. Toro, Mycotaxon 35: 220. 1989.

Dentiscutata cerradensis (Spain & J. Miranda) Sieverd., F.A. Souza & Oehl, **comb. nov.** (FIG. 42)
MB 511973
BASIONYM: *Scutellospora cerradensis* Spain & J. Miranda, Mycotaxon 60: 130. 1996.

Dentiscutata hawaiiensis (Koske & Gemma) Sieverd., F.A. Souza & Oehl, **comb. nov.** (FIG. 41)
MB 511972
BASIONYM: *Scutellospora hawaiiensis* Koske & Gemma, Mycologia 87: 678. 1995.

Dentiscutata heterogama (T.H. Nicolson & Gerd.) Sieverd., F.A. Souza & Oehl, **comb. nov.** (FIG. 44)
MB 511975
BASIONYM: *Endogone heterogama* T.H. Nicolson & Gerd., Mycologia 60: 319. 1968.
≡ *Gigaspora heterogama* (T.H. Nicolson & Gerd.) Gerd. & Trappe, Mycologia Memoir No. 5: 31. 1974.
≡ *Scutellospora heterogama* (T.H. Nicolson & Gerd.) C. Walker & F.E. Sanders, Mycotaxon 27: 180. 1986.

Dentiscutata nigra (J.F. Redhead) Sieverd., F.A. Souza & Oehl, **comb. nov.**
MB 511969 (FIG. 38)
BASIONYM: *Gigaspora nigra* J.F. Redhead, Mycologia 71: 187. 1979.
≡ *Scutellospora nigra* (J.F. Redhead) C. Walker & F.E. Sanders, Mycotaxon 27: 181. 1986.

Dentiscutata reticulata (Koske, D.D. Mill. & C. Walker) Sieverd., F.A. Souza & Oehl, **comb. nov.** (FIG. 39)
MB 511970
BASIONYM: *Gigaspora reticulata* Koske, D.D. Mill. & C. Walker, Mycotaxon 16: 429. 1983.
≡ *Scutellospora reticulata* (Koske, D.D. Mill. & C. Walker) C. Walker & F.E. Sanders, Mycotaxon 27: 181. 1986.

Dentiscutata scutata (C. Walker & Dieder.) Sieverd., F.A. Souza & Oehl, **comb. nov.**
MB 511974 (FIG. 43)
BASIONYM: *Scutellospora scutata* C. Walker & Dieder., Mycotaxon 35: 357. 1989.

Fuscutata Oehl, F.A. Souza & Sieverd., **gen. nov.**
MB 511963

Sporae terminaliter efformatae anguste adiacetae ad cellulas sporogeneas; cum tunicis tribus; scutellum germinale coniunctum ad tunicam interiorem, flavo-brunneum ad brunneum; ovale vel ovoidum vel viola-forme, cum 2 lobis et depressionibus germinatione; formans structuras mycorrhizarum arbuscularum.

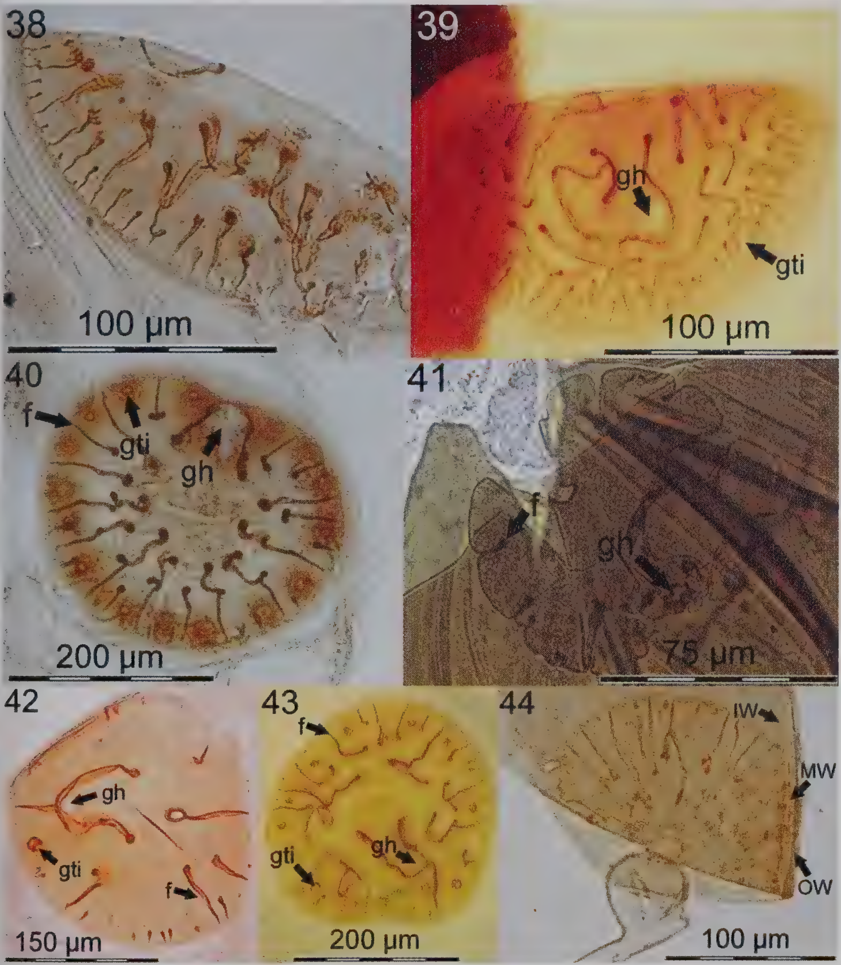
38
100 µm
39
gh
gti
100 µm
40
f
gti
gh
200 µm
41
f
gh
75 µm
42
gh
gti
f
150 µm
43
f
gti
gh
200 µm
44
IW
MW
OW
100 µm

Plate 7—*Dentiscutata* with complex structured, yellow-brown to brown germination shields (gs) showing several to many (8–30) compartments, separated by large folds (f); often one initial germ hole (gh) and several to many (8–30) germ tubes initiations (gti) visible; germ tubes emerge from one or two gti during germination; shield periphery conspicuously dentate in planar view.

Fig. 38. Type species *D. nigra*. Fig. 39. *D. reticulata*. Fig. 40. *D. biornata*. Fig. 41. *D. hawaiiensis* Fig. 42. *D. cerradensis*. Fig. 43. *D. scutata* sensu Silva et al. (2006b). Fig. 44. *D. heterogama*.

Etymology: from the Latin fu(scus) (= brown), and scutata (= 'shielded'), referring to the color of the germination shield formed on the inner spore wall.

Key characters: Sporocarps are unknown. Single spores formed on bulbous sporogenous cells which are terminally formed on the subtending hypha that arises from mycelia hyphae. Outer spore wall three- to four layered. Pore between the spore and sporogenous cell is narrow and usually closed by a plug formed by spore wall material. Two hyaline walls ('middle wall' and 'inner wall') form de novo during spore formation and have 1–2 and 2–3 layers, respectively. Germination shield generally formed on the outer surface of the innermost wall or beneath a thin outer layer of the inner wall, yellow-brown to brown, generally ovoid to violin-shaped to heart-shaped, consisting of 2 lobes and folds; both lobes with a germ tube initiation ('gti', about 3-6 μm in diam). Spore germination generally from one gti; germ tube penetrates from there the middle and outer spore wall. In the subtending hypha one to several septa are formed in some distance to the sporogenous cell. Auxiliary cells in the hyphal mycelium as far as they are known knobby without spines on the surface. Forming typical arbuscular mycorrhizae, vesicle formation in roots so far unknown.

TYPE SPECIES: *Fuscutata heterogama* Oehl et al.

Key to *Fuscutata* species

1a Spore without surface ornamentation on outer wall............................2
1b Spore with surface ornamentation on outer wall 3

2a Spores hyaline to white; oblong-ellipsoid to long ellipsoid, 280–580 × 210–370 μm in diam...*F. savannicola*
2b Spores dark orange brown to dark red brown, 140–220 μm in diam, outer and innermost wall strongly staining in Melzer's reagent...........*F. rubra*

3a Spores hyaline to subyaline, globose to oval, μm in diam; spores with fine spiny ornamentation on the surface of the outer wall........... *F. trirubiginopa*
3b Spore with papillae ornamentation on the surface of the outer wall; spores red brown to dark brown, globose to oval, 159–295 μm in diam ..... *F. heterogama*

Fuscutata heterogama Oehl, F.A. Souza, L.C. Maia & Sieverd., **sp. nov.**
MB 511964 (FIGS. 45–46)

Sporae singillatim in solo efformatae anguste adiacetae ad cellulas sporogeneas subterminales vel intercalares, brunneae vel rubro-brunneae vel oscuro-brunneae, globosae, 165–280 μm in diametro, vel subglobosae vel ovale (159–265 × 195–295 μm); sporae cum tunicis tribus: tunica exterior stratis tribus in totum 7.0–11.5 μm crassa, coniuncta tunicam cellulae sporogeneae et tunica hyphae; stratum exterius tunicae exterioris hyalinum, evanescens, 1.1–2.1 μm crassum; papillibus ornatum altis 1.1–2.1 μm et 0.9–1.5(–2.5) μm latis ornatum; stratum secundum brunneum vel rubro-brunneum vel oscuro-brunneum, laminatum, 5.5–8.5μm crassum; stratum interius tunicae exterioris brunneum vel rubro-brunneum, subtile; tunica media et tunica interior de novo formans; cum stratis hyalinibus; tunica media duobus stratis in totum 2.1–2.8 μm crassum; tunica interior tribus stratis, 2.1–3.4 μm crassa; stratum medium et stratum interiore tunicae exterioris purpureo-brunneum vel oscuro-brunneum colorans, stratum medium tunicae interioris purpureo colorans reagente Melzeri; scutellum germinale coniunctum ad tunicam interiorem, flavo-

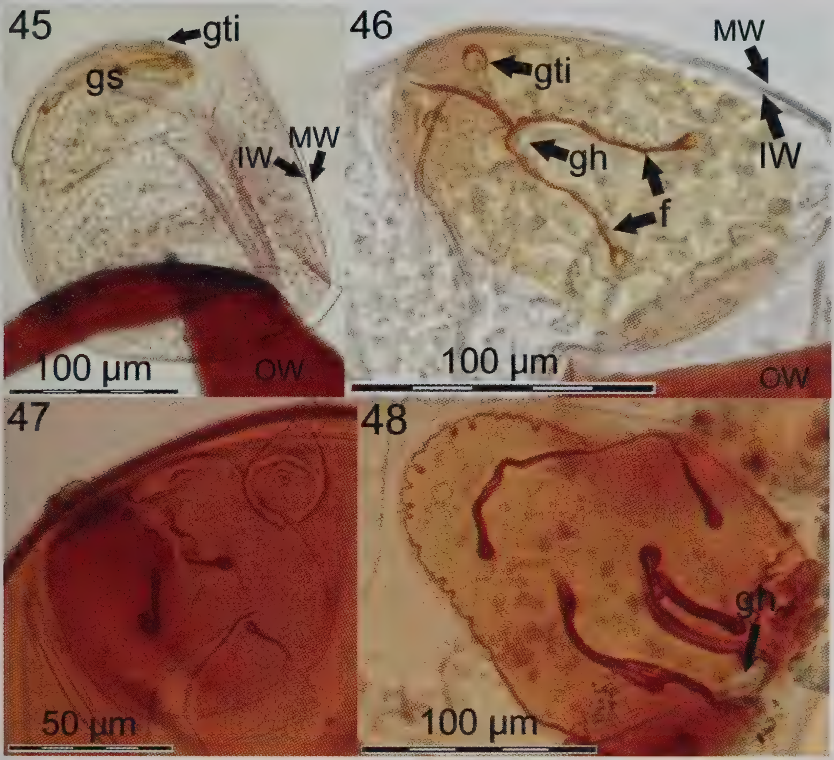
45
gti
gs
IW
MW
100 µm
OW
46
MW
gti
gh
IW
f
100 µm
OW
47
50 µm
48
gh
100 µm

Plate 8—*Fuscutata* with yellow-brown to brown germination shields and three walls (ow, mw and iw). . Germination shields are generally bi-lobed with a germ hole (gh) and two germ tube initiations (gti). figs. 45–46. Type species *F. heterogama*. fig. 47. *F. rubra*. fig. 48. Old shield, in *F. savannicola*.

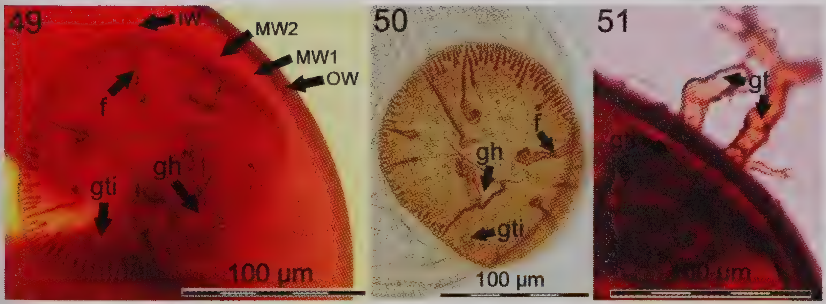
49
IW
MW2
MW1
OW
f
gh
gti
100 µm
50
f
gh
gti
100 µm
51
gt
gh
100 µm

Plate 9—figs. 49–51: *Quatunica* with one species, *Q. erythropus*: Complex structured, yellow-brown to brown germination shields (gs) in spores of type species *Q. erythropus* having four spore walls (ow, mw1, mw2 and iw). Germination shield on the outer surface of iw. Shields with many (> 10) compartments, separated by large folds (f); generally one initial germ hole (gh) and several germ tubes initiations (gti) visible from where one or few germ tubes per spore emerge during germination (fig. 51); periphery of shield walls conspicuously dentate.

brunneum ad brunneum; ovale vel ovoid vel viola-forme, simplex bilobatumque cum 2 depressionibus germinationis; structurae mycorrhizarum arbuscularum formans.

Type specimens: BRAZIL. Pernambuco. Município de Camaragibe. Location: Aldeia. ***holotype*** (84-8401) and isotype (84-8402 & 84-8403) specimens deposited at URM (Recife, Brazil); isolated from field samples (10 June 1997) and established in a pure culture maintained at URM and INVAM; isotypes 84-8404& 84-8405 deposited at Z+ZT (accession number ZT Myc 642), and 84-8406 & 84-8407 deposited at OSC (OSC #134'504).

Etymology: heterogama referring to *Endogone heterogama* with which this new species has been very often confused.

Commentary: A detailed English species description of *F. heterogama* is not needed, since several isolates of the new species were intensively studied during the last 20 years (e.g. Franke & Morton 1994, Jeffries et al. 2007). Spores are globose (165–280 µm in diam) to subglobose to oval (159–265 × 195–295 µm) to rarely irregular, reddish-brown to dark red-brown to dark brown, with three spore walls (ow, mw and iw). The ow three-layered (owl1-3: owl1 hyaline, semi-persistent to persistent, 1.1–2.1 µm thick, with papillae projections, 0.9–1.5(–2.5) µm in diameter and at 0.8–2.4 µm distance from each other; owl2 red-brown to dark brown, laminate. 5.5–8.5 µm thick, owl3 subtile, concolorous with owl2; mw hyaline, bi-layered, in total 2.1–2.8 µm thick; iw bi-to-tree-layered, in total 2.1–3.4 µm thick; owl2 & owl3 and iwl2 staining dark red-brown and purple, respectively, in Melzer's reagent. Sporogenous cell globose to oblong, 32–51 × 31–45 µm; germ shield yellow-brown to brown, simple, bi-lobed, oval to ovoid to violin-shaped (75–105 × 55–75 µm) to rarely irregular, generally with 2 lobes rarely showing 4 folds; shield periphery generally smooth, rarely with scarse dentate structures. Forms typical arbuscular mycorrhiza without intraradical vesicles but extraradical auxiliary cells in the hyphal mycelium. *Fuscutata heterogama* can be easily distinguished from *D. heterogama* by spore color and especially by the morphology of the shield (see above; compare figs. 45–46 with fig. 44). It can be easily distinguished from other *Fuscutata* spp. by the ornamentation on the outer spore surface (see identification key below).

Distribution: *Fuscutata heterogama* has a major distribution in warmer climates (Mediterranean, Subropical and Tropical climates) but was confused with *Endogone heterogama* which might have a less broad distribution. The new species is frequent in Southern America as we have found it several times in Colombia and Brazil. It was recently found also in Benin (West Africa; Hountondji & Oehl, unpublished, Tchabi et al. 2008).

Other specimens examined: COLOMBIA. Eastern Plains. Sieverding collection. UNITED STATES. Florida. Illionois. Specimens deposited at INVAM, and specimens prepared by F. Oehl during his visit at INVAM in 2002 (slides deposited at Z+ZT). Specimens of the Embrapa Agrobiologia germplasm collection, Seropédica, Brazil, CNPAB2. BENIN: Guinea and Sudan savannas under yam and peanuts (Tchabi et al. 2008).

Fuscutata rubra (Stürmer & J.B. Morton) Oehl, F.A. Souza & Sieverd., **comb. nov.** (FIG. 47)

MB 511965

BASIONYM: *Scutellospora rubra* Stürmer & J.B. Morton, Mycol. Res. 103: 951. 1999.

Fuscutata savannicola (R.A. Herrera &Ferrer) Oehl, F.A. Souza & Sieverd., **comb. nov.** (FIG. 48)

MB 511966

BASIONYM: *Gigaspora savannicola* R.A. Herrera & Ferrer, Rev. Jard. Bot. Nacional, Habana. 1: 57. 1981.

≡ *Scutellospora savannicola* (R.A. Herrera & Ferrer) C. Walker & F.E. Sanders, Mycotaxon 27: 180. 1986.

Fuscutata trirubiginopa (X.L. Pan & G.Yun Zhang) Oehl, F.A. Souza & Sieverd., **comb. nov.**

MB 511967

BASIONYM: *Scutellospora trirubiginopa* X.L. Pan & G.Yun Zhang, Mycosystema 16: 169.

Quatunica F.A. Souza, Sieverd. & Oehl, **gen. nov.**

MB 511976

Sporae terminaliter efformatae anguste adiacetae ad cellulas sporogeneas, quartuoribus tunicis; scutellum germinale coniunctum ad tunicam interiorem, flavo-brunneum ad brunneum, cum 8–30 compartimentibus et depressionibus germinationis; formans structuras mycorrhizarum arbuscularum.

ETYMOLOGY: From the Latin: 'qua' abreviation from quartuor (four) and 'tunica' (wall) referring to the four spore walls, a unique character in *Glomeromycota.*

KEY CHARACTERS: Sporocarps are unknown. Spores singly formed on bulbous sporogenous cells that are formed terminally on a subtending hypha that arises from mycelia hyphae. Spores have 4 walls. Outer spore wall three- to four-layered and continuous at least in part with the wall of the sporogenous cell; pore between the spore and sporogenous cell is narrow and usually closed by a plug formed by outer spore wall material. Two hyaline middle walls and a hyaline inner wall form de novo during spore formation. Germination shield generally arising on the outer surface of the inner wall or beneath a thin outer layer of the inner wall, yellow-brown to brown, generally ellipsoid to oval, or rarely reniforme to cardioforme, usually with a many (8–30) large folds separating the shield into 8–30 'small compartments'; each small compartment generally with one germ tube initiation ('gti). From one or few gti germ tubes may arise penetrating the middle walls and the outer wall; the periphery of shield wall usually conspicuously dentate in planar view. One to several septa often formed in the subtending hypha in some distance to the sporogenous cell.

Auxiliary cells formed in hyphal mycelium as far as they are known knobby without spines on the surface. Forming typical arbuscular mycorrhizae, vesicle formation in roots so far unknown.

TYPE SPECIES: *Quatunica erythropus* (Koske & C. Walker) F.A. Souza et al.

Key to *Quatunica* species

1a Spores white-yellow, to yellow-brown, 340–640 µm in diam
. . . . *Q. scutata* (*S. scutata* sensu Silva et al. 2006b) [non editum]
1b Spores orange-brown to dark red brown, 200–650 µm in diam . . . . *Q. erythropus*

Quatunica erythropus (Koske & C. Walker) F.A. Souza, Sieverd. & Oehl, **comb. nov.** (PLATE 9)

MB 511977

BASIONYM: *Gigaspora erythropus* Koske & C. Walker, Mycologia 76: 250. 1984.
≡ *Scutellospora erythropus* (Koske & C. Walker) C. Walker & F.E. Sanders, Mycotaxon 27: 181. 1986.

Discussion

Molecular analyses, based almost exclusively on 18S rRNA genes, have provided the means to describe the phylum *Glomeromycota* and to reorganize almost entirely the glomeromycotan phylogeny (Schüßler et al. 2001). This resulted in a new order, the *Diversisporales*, validly described by Walker & Schüßler (2004), which contains species and genera that can be distinguished morphologically by the different spore formation types: acaulosporoid, entrophosporoid, gigasporoid or glomoid. Such spore formation differences earlier served as the basis for higher order ranks (Morton & Benny 1990). Only recently, new families and genera have been proposed for the *Glomeromycetes* based on combined molecular genetic and spore morphological data. Oehl & Sieverding (2004) separated the *Pacispora* genus from *Glomus* in the *Glomeraceae*, order *Glomerales*, based on morphological and germination characteristics, and Walker et al. (2004) cited molecular data in describing the new *Pacisporaceae* family in the order *Diversisporales* (Walker & Schüßler 2004). Sieverding & Oehl (2006), Spain et al. (2006) and Walker (2007) also referred to molecular data to review *Entrophospora* and the *Archaeosporaceae*, which prompted a taxonomic reorganization of new fungal genera and families in the *Archaeosporales* based on 18S and ITS rRNA-generated phylogenies (Walker et al. 2007).

We used published DNA sequences available from 18S and 25S rDNA for a total of 17 former *Scutellospora* spp. and 7 *Gigaspora* spp. (FIGS. 10–11) and morphological data from all previously described *Scutellospora* species as a basis for separating the new families and genera in the *Diversisporales* from the *Gigasporaceae*. The molecular analyses showed that *Gigasporaceae*

Table 3. Spore morphology and spore wall characteristics in *Scutellospora*, *Racocetra*, *Cetraspora*, *Fuscutata*, *Denticutata* and *Quatunica*

	Spore size (µm)	Spore shape	Spore color	Suspensor size (µm)	# of wall layers on OW-MW-IW^{A}	Ornamentation on outer wall	Melzer's rxn on wall layer ^{A,B}
Scutellospora							
S. arenicola	160–360 × 120–310	Subglobose to irregular	Yellow brown to orange brown	35–47	3–2–2	No	OWL2 IWL2
S. aurigloba	200–400 × 130–420 (–520)	Globose to rarely polymorph	Yellow to dull yellow	40–70	3–2–2	No	IWL2
S. calospora	90–290 × 125–510	Ellipsoid to ovoid to cylindrical, rarely globose	Hyaline to light yellow	22–35 × 28–48	3–2–2	No	IWL2
S. crenulata	120–170	Globose to subglobose to rarely ellipsoid	Ochraceus to ochre to yellow	22–46 × 18–27	3-1-2	Warts on domed papillae	OWL2 MWL2 IW
S. dipapillosa	150–165 × 135–180	Globose to subglobose to irregular	Pale orange brown to dark orange brown	27–40	3–2–2	Double, warts and blunts	Unknown
S. dipurpurescens	150–240	Globose to subglobose, to rarely ellipsoid	Yellow to greenish yellow	26–30	3–1–2	No	IWL2
S. nodosa	160–270	Globose to subglobose, rarely ovoid	Hyaline to pale yellow	27–50	3–2–2	Knobby	OWL2 MW IW
S. pernambucana	105–135 × 120–150	Globose to subglobose to rarely oval	Dark yellow to brown yellow	31–48 × 26–43	3–2–2	No	IWL2
S. projecturata	100–175 × 105–185	Globose to subglobose to rarely ellipsoid	Golden, dull yellow, ochre to sienna	32–60 × 29–47	3–1–2	Straight or hooked digitations	IW
S. tricalypta	300–390; 285 × 455	Globose to subglobose to ellipsoid	Brown to dark brown	14–47	3–2–2	No	Unknown

TABLE 3, CONTINUED

	Spore size	Spore shape	Spore color	Suspensor size	# wall layers	OW Ornamentation	Melzer's rxn
Racocetra							
R. alborosea	200–210 × 265–345	Globose to subglobose to irregular	Pale pink to dark pink ^{c}	21–50	3–0–2	No	Unknown
R. castanea	165–370 × 175–375	Globose to subglobose, or ovoid	Ochraceous to sienna	38–51	3–0–2	No	OWL1-2
R. coralloidea	300–395 × 320–455	Globose to subglobose to ellipsoid	Orange-red to dark orange brown	55–64	3–0–2	flattened warts with angular margins	OWL2, hardly to discern (spore color)
R. fulgida	160–240	Globose to subglobose	Hyaline to pale straw or pale yellowish-cream	26–46, sometimes darker than spore	3–0–2	No	OWL2
R. gregaria	250–450	Globose to subglobose	Red brown to dark brown	39–80	3–0–2	Rounded warts	OWL2
R. minuta	95–180	Globose to subglobose to irregular	Brown to dark brown to opaque	22–31	3–0–2	Concave pits in tips of rounded warts	Unknown
R. persica	270–360 × 280–384	Globose to subglobose to ellipsoid	Pale pinkish-orange to brownish orange	45–62 × 47–125	3–0–2	fine spines	OWL2
R. verrucosa	220–480	Globose to subglobose	Pale straw to yellow to yellow brown	55–100 × 35–70	3–0–2	verrucose warts	OWL2
R. weresubiae	125–265 × 135–415	Globose to subglobose to irregular	Pale pink to deep pink ^{c}	32–50	3–0–2	No	OWL2 (yellow); not IWL2! [type material!]
Cetraspora							
C. armeniaca	140–240	Globose to subglobose	Apricot yellow to yellow brown	32–42	3–2–2	No	OWL2 MWL2 IWL2
C. gilmorei	200–320	Globose to subglobose to rarely ellipsoid	Hyaline ^{D}, suspensor light brown	27–40,	3–2–2	No	IWL2
C. pellucida	60–240 × 60–240 (–410)	Globose to subglobose to ellipsoid	Hyaline, white to pale grey	10–50	3–2–2	No	OWL2 IWL2
C. spinosissima	130–230 × 120–210	Globose to subglobose to broadly ellipsoid	Ochraceous to fulvous to rust	19–32	3–1–2	Fine spines	IWL2
C. striata	130–185 × 115–155	Globose to subglobose	Ochraceous yellow of a pinkish tint	22–29	3–1–3	Muri, finger-print-like processes	IWL2

TABLE 3, CONCLUDED

	SPORE SIZE	SPORE SHAPE	SPORE COLOR	SUSPENSOR SIZE	# WALL LAYERS	OW ORNAMENTATION	MELZER'S RXN
Fuscutata							
F. heterogama	159–265 × 195–295	Globose to ellipsoid to irregular	Brown to reddish brown	32–51 × 31–45	3–2–2	'minute projections'	OWL2 IWL2
F. rubra	140–220	Globose to subglobose	Dark orange brown to red-brown	18–35	3–2–2	No	OWL2 IWL2
F. savannicola	285–585 × 210–365	Oblong to ellipsoid	Hyaline to white	33–51	3–2–2	No	IWL2
F. trirubiginopa	210–310 × 210–300	Globose to subglobose	Hyaline to white, suspensor (reddish-) brown	ca. 42	3–2–2	Fine spines	OWL2 MW IWL2
Dentiscutata							
D. biornata	280–385 × 340–415	Globose to subglobose	Yellowish-brown to brown	(30–)50–65	3–1–2	Blunt projections on OWL1 and OWL3	OWL2 IWL2
D. cerradensis	(170–) 230–365	Globose to ovoid	(Sub)hyaline to straw with age, suspensor brown	35–55 × 50–75	4–2–2	Fine 'papillae'	OWL2 MW IWL2
D. hawaiiensis	200–360 × 180–290	Subglobose to irregular	Pale orange brown to dark orange brown	50–65	3–2–2	No	IWL2
D. heterogama	150–210; 175 × 255	Globose to ellipsoid to irregular	Pale brown to yellow brown	21-26	3–2–2	'Minute projections'	Unknown
D. nigra	295–500 (–1050)	Globose to subglobose	Dark brown to black	40–60 × 80–120	3–2–2	Largely pored pits over sinuous ornamentation	IWL2
D. reticulata	205–470 × 185–340	Globose to subglobose	Orange-brown to dark red brown	45–87 × 85–140	4–2–2	Spines between ridges of a reticulum	IWL2
D. scutata	340–640, 350–670 × 350–715	Globose to subglobose to ellipsoid to oblong	Hyaline to white, suspensor brown	47–100 × 90–125, yellow brown	3–2–2	No	OWL2 IWL2
Quatunica							
Q. erythropus	170–551 × 205–660	Globose to subglobose to ellipsoid to oblong	Orange brown to dark red brown	60–125 × 30–60	3– (2+2) –2	No	MW2-L2 IWL2

[A] outer, middle and inner wall (OW, MW, IW) with different layers (OWL1-4, MWL1-2, IWL1-3); *Q. erythropus* has two bi-layered middle walls (MW1 and MW2). Recent analyses suggest that all *Scutellosporaceae*, *Racocetraceae* and *Dentiscutataceae* species have a three layered IW including a thin innermost layer IWL3. [B] if OWL2 stains also thin OWL3 generally stains in Melzer's reagent; [C] strongly darkened in mounted slides of type material; [D] strongly darkened in type material after storage in lactophenol.

Table 4. Morphology of germination shields and auxiliary cells in *Scutellospora*, *Racocetra*, *Cetraspora*, *Fuscutata*, *Dentiscutata* and *Quatunica*

	Germ shield (µm)	Shape of germ shield	Color of germ shield	Size (µm) & shape of auxiliary cells
Scutellospora				
S. arenicola	120–140	Bi-lobed, violin-shaped to oval to cardioid, with two germ tube initiations (gti)	Pale yellow brown to brown	20–41 × 20–40; clusters of 2-7 cells
S. auriglоba	65–85 × 65×105	Bi-lobed; violin-shaped to oval to cardioid, with two gti	Hyaline to light yellow	Aggregations about 100 µm; in clusters of 3-9 knobby cells
S. calospora	35–70 × 50–90	Bi-lobed, violin-shaped, with two gti	Hyaline to light yellow	18–22 × 31–33; irregular, singly or in loose clusters (2-4 cells)
S. crenulata	50–100 × 75–120	Mono-(to bi-(?))lobed, oval to ellipsoid to rarely cardioid to irregular, with 1(–2?) gti	Hyaline	Unknown
S. dipapillosa	60–80 × 85–95	Bi-lobed, violin-shaped, with two gti	Hyaline to light yellow	Cluster of 12–30 knobby cells
S. dipurpurescens	60–85 × 90–140	Bi-lobed, violin-shaped to oval to cardioid, with two germ tube initiations	Hyaline to light yellow	16–25 × 22–32; globose to obovate to irregular
S. nodosa	65–80 × 130–140	Bi-lobed, oval to cardioid, with two germ tube initiations	Hyaline to pale yellow	18–33; loose clusters of 2–5 cells
S. pernambucana	50–85 × 63–98	Mono-lobed, orb-like or coiled, with one gti	Hyaline to subhyaline to rarely light yellow	Unknown
S. projecturata	50–90	Mono-lobed, coiled, with one (to two?) gti	Hyaline to light yellow	Unknown
S. tricalypta	95 × 150	Bi-lobed, violin-shaped to oval, with two gti	Hyaline to pale yellow[a]	Unknown
Racocetra				
R. alborosea	Unknown	Unknown	Unknown	Unknown
R. castanea	180–210	Multiple-lobed (5–12), with multiple gti	Hyaline to light yellow	21–28 × 23–32; single or in clusters of 2–6 knobby cells
R. coralloidea	80–140	Multiple-lobed (4–8), with multiple gti initiations	Hyaline to pale yellow	25–30 × 30–40; a single knobby, later coralloid cell
R. fulgida	40–90 × 80–130	Multiple-lobed (4–8), with multiple gti	Hyaline to light yellow	20–25 × 25–37; in clusters of 5–13 knobby cells
R. gregaria	80–150	Multiple-lobed (4–8), with multiple gti	Hyaline to pale yellow	14–32 × 22–48; cluster of 3–13 knobby cells
R. minuta	Rarely observed	Unknown	Hyaline to light yellow	Unknown
R. persica	130–240 × 60–180	Multiple-lobed (4–8), with multiple gti	Hyaline to light yellow	22–27; in clusters of 4–6 knobby cells
R. verrucosa	80–90 × 150–210	Multiple-lobed (4–8), with multiple gti	Hyaline to light yellow	12–30; in clusters of 5–15 knobby cells

R. weresubiae	70–80 × 100	(Multiple)-lobed (4–8), with multiple gti	Hyaline to subhyaline	17–33 × 25–40; in clusters of 5–14 knobby cells
Cetraspora				
C. armeniaca	45–70 × 80–95	Multiple-lobed (4–10), with multiple gti	Hyaline to pale yellow	15–32; in clusters of 2–12 knobby cells
C.gilmorei	80–140 × 110–175	Multiple-lobed (4–8), with multiple gti	Hyaline to pale yellow	15–25; in loose clusters of 3–14 knobby cells
C. pellucida	110–140 × 125–160	Multiple-lobed (4–8), with multiple gti	Hyaline to rarely pale yellow	12–15; in clusters of 1–12 knobby cells
C. spinosissima	70–130 × 90–140	Multiple-lobed (4–12), with multiple gti	Hyaline to pale yellow	Unknown
C. striata	72 × 64	Multiple-lobed (4–12); with multiple gti (?)	Hyaline to subhyaline (to pale yellow)	Unknown
Fuscutata				
F. heterogama	75–105 × 55–75	Bi-lobed, violin-shaped to oval to ovoid, with two gti	Yellow brown to brown	16–29 × 20–43; in clusters of 1–11 'flattened' cells
F. rubra	60–70 × 80–110	Bi-lobed, violin-shaped to oval to ovoid, with two gti	Pale yellow brown to brown	15–28; Clusters of 5–11 knobby cells
F. savannicola	100–160 × 90–140	Bi-lobed, oval to cardioid, with two gti	Pale yellow brown to brown	15–29; in clusters of 3–20 cells
F. trirubiginopa	132 × 106	Bi-lobed (?), circular to ovoid; with two gti (?)	Reddish-brown	Unknown
Dentiscutata				
D. biornata	(110–)185–240 × (110–)185–275	Ellipsoid, 12–30 small compartments and gti; dentate	Brown	32–48 × 37–48; in clusters of 10–20 knobby cells
D. cerradensis	90–155 × 100–175	Cardioid to ellipsoid, 6–10 small compartments and gti; slightly dentate	Pale yellow brown to brown	20–33; cluster of 1–12 rounded to knobby cells
D. hawaiiensis	40–60 × 60–80	Ellipsoid, 8–12 compartments and gti; slightly dentate	Yellow brown to orange brown	40–55; in clusters of 4–6 knobby cells
D. heterogama	90–120 × 130–160	Ellipsoid, 12–24 small compartments and gti; dentate	Yellow brown to brown	16–27 × 20–31; in clusters of 1–10 'flattened' cells
D. nigra	130–170 × 180–240	Ellipsoid, 12–24 small compartments and gti; dentate	Yellow-brown to brown	21–36; in clusters of 3–12 knobby cells
D. reticulata	94–156 × 156–208	Ellipsoid to circular, to rarely reniform[b]; 12–24 small compartments and gti; dentate	Yellow-brown to brown	25–30 × 30-40; in clusters of 10–40 knobby cells
D. scutata	240–325 × 205–305	Ellipsoid oval, cardioid or circular, 12–18 small compartments and gti; dentate	Yellow-brown to brown	17–55 × 15–45; in clusters of 4–25 smooth to knobby cells
Quatunica				
Q. erythropus	125–200 × 175–190	Ellipsoid to oval, 8–20 small compartments and gti; dentate	Yellow-brown to brown	18–27; in clusters of 6–15 knobby cells

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[a] IW and germ shield has darkened in type material after being mounted in the medium Ferrant, [b] the reniform type might be an artifact due to a special position of the germ shield when spore was crushed.

are phylogenetically closer to *Racocetraceae* and *Dentiscutataceae* than to *Scutellosporaceae* and suggested that *Scutellosporaceae* is basal among the four families that produce spores from a bulbous sporogenous cell. Contrary to the evolutionary hypotheses expressed by Morton (1990) and Morton & Benny (1990), *Gigasporaceae* may well have co-evolved with *Racocetraceae* and *Dentiscutataceae*. Morphologically, however, *Gigasporaceae* differ as greatly from *Racocetraceae* and *Dentiscutataceae* as *Pacisporaceae* differs from *Glomeraceae*.

In this study, germination structures and spore wall composition were the morphological characters that were supported by the molecular data. On their basis the species could be organized within new or re-described genera and families. This was easily done for *Gigaspora*, the only genus in the *Gigasporaceae*, as the *Gigaspora* spore has only one wall and no germination shield. However, it was more difficult to classify species forming a germination shield. While striking genetical differences between the *Scutellospora* species have become recognized (e.g. Simon et al. 1992, Helgason et al. 1998, Lanfranco et al. 1999, de Souza et al. 2005), researchers apparently have encountered difficulties in grouping the species along genetic lineages. A recently published key (Silva et al. 2006b) still focuses exclusively on spore size, spore wall ornamentation, and wall characteristics. For the most part, the known morphological differences in germ shields (Walker & Sanders 1986, Spain et al. 1989) have been ignored in species taxonomies, so that this represents the first time that germ shields have been observed, photographed, and used for taxonomic classification. Little is known about the ontogeny of germination shields of the different genera, which has been actually only described for *S. calospora* by Walker & Sanders (1986). We do not know about the ontogeny of shield formation of *Racocetra*, *Cetraspora*, *Fuscutata* and *Dentiscutata*, nor is this knowledge necessary to identify the genera. Germ shield morphology alone is sufficient clear, and stable.We confirmed that germ shield morphology does not change with spore age for all examined species, as we could examine numerous spores from different populations and sometimes very different ecosystems (see TABLE 1: *S. calospora*, *S. aurigloba*, *R. fulgida*, *R. gregaria*, *R. verrucosa*, *C. pellucida*, *F. heterogama*, *D. reticulata*, *D. biornata*).

Researchers who attempt to determine colors of very old field spores and shapes when germination shield is hidden or incompletely visible may encounter difficulties, particularly as the germ shield can readily be observed only when seen in planar view. Spain et al. (1989) describe how to reveal germ shield structure better by slightly moving the cover slide on a not yet completely hardened fixative and by separating spore walls from crushed spores under the stereomicroscope. There are a few species where the color of the germ shield may be ambiguous because parts of the originally hyaline shield brown slightly over time on specific storage media (as in *R. coralloidea* and *C. gilmorei*) or the spore wall turns so dark brown that the shield can no longer be seen (as in *S. savannicola* herbarium specimens). Nonetheless, the germ shield folds are in most cases easy to recognize, particularly when the shield is either very simple (e.g. *Scutellospora* spp.) or very complex (*Dentiscutata* spp.). Some experience is needed to identify the wavy folded, hyaline, multi-compartmented shields of *Racocetra* and *Cetraspora* (FIG. 5 + PLATES 5–6). In such shields it is often easier to count the number of germ tube initiations (gti) within the shield compartments. Determining the number of middle walls may also confuse, particularly during separation when the inner lamina of the outer wall can be mistaken for a middle wall, making differentiation between *Racocetra* and *Cetraspora* (or *Dentiscutata* and *Quatunica*) difficult. Here it is a matter of crushing several spores so as to determine whether the wall layers stick together or are easily separated. Finally, other spore features — size, color, wall ornamentation, swelling of wall layers in PVLG based mountants, staining in Melzer's reagent — may also be used to identify the species (and thus genus) morphologically, as done previously (Silva et al. 2006b). Our own experience with the new keys presented in this paper convinces us that identification of species with bulbous sporogenous cells will be much easier now that germ shields are used as diagnostic characters. Nonetheless, we suspect that the genera presented here may contain additional groups with diverging shield characters and possibly divergent phylogenies that may justify — in the future — erection of new genera based on the number of lobes and gti or due to shield composition (e.g. in *Scutellospora* and *Dentiscutata*, TABLE 4).

During our study we faced several difficulties related to the availability and quality of live and herbarium specimens. Pure cultures were either unavailable for most of the as-yet unsequenced species, (e.g. *R. minuta*, *R. alborosea*, *F. savannicola*) or pure cultures got lost with time (e.g. *D. biornata*). In a few cases the herbarium type material was so poor in both spore number and spore quality after 20–40 years of storage (e.g. for *R. minuta*, *R. alborosea,* and other species described before 1990) that germ shields could not be found in the type material. In a few other cases, the spores mounted or preserved in the type material had obviously been immature, since the germ shield and sometimes even the inner wall could not be detected on the majority of the spores. In such cases we had to rely for the identification of shield morphology either on the original species description or on our own specimens collected in different parts of the world. Some species, e.g. *R. alborosea* and *R. weresubiae,* may be conspecific but it was not our aim to correct this. We also noted that some species should be redescribed (e.g. *S. tricalypta*), also not the goal of this paper. There was, nonetheless, an urgent need to separate the species presented in the type specimens for *S. heterogama* (Nicolson & Gerdemann 1968) from those erroneously identified as such. Germ shield morphology clearly showed that the two 'heterogama' species belong to two different genera, *Fuscutata* and *Dentiscutata* (see description above).

In conclusion, the previously most commonly used morphological spore characters like spore size, color and staining of different spore walls in Melzer's reagent or expanding of wall layers in lactic acid based mountants (Franke & Morton 1994, Morton 1995) could not explain the rDNA-based phylogenetic clades (PLATES 2–3; also Walker et al. 2004, de Souza et al. 2005, Ahulu et al. 2006, Redecker et al. 2007). We have not investigated for this study whether there are differences in the staining behaviour of the mycelium in the roots among our new segregate genera. Such differences are important in *Paraglomeraceae* and *Archaeosporaceae* (Morton & Redecker 2001), but we found no literature indicating that this is the case in *Gigasporaceae*. We also did not investigate whether there are specific differences between the genera in the morphology of their auxiliary cells in the external root mycelium. Walker & Sanders (1986) noted that such differences are only minor in *Scutellospora* and then only consistent in differentiating *Gigaspora* from *Scutellospora*. Also, color of the mycelium in soil may be different: some species (e.g., *F. heterogama*, *D. reticulata*) form light brown to brown walled mycelium while others, like *R. castanea*, form mycelia with hyaline walls (pers. obs.). Information on all these characters is available for only a few species and was considered unnecessary to reorganize the genera presented here. Nevertheless, we propose that living pure cultures be established and that detailed studies of the auxiliary cells on extraradical mycelia and the ontogeny of germination shields in different genera be carried out; studies of genetical and ecological characters are also recommended. Unfortunately, much basic biology remains unknown in the *Glomeromycetes,* including germination, the process so intimately linked with the fitness and survival of these obligatory biotrophic symbiotic fungi. Although axenic cultures may prove useful in the future, we believe that the important spore characters must be observed in soil-grown spores that represent spores found under field conditions that ecologists and taxonomists encounter in real life.

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Scutellospora pernambucana, a new fungal species in the *Glomeromycetes* with a diagnostic germination orb

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Abstract — A new species of the arbuscular mycorrhiza-forming *Scutellosporaceae* (*Glomeromycetes*), described here as *Scutellospora pernambucana*, forms globose to subglobose (rarely oval), yellow to brown-yellow glomerospores terminally on sporogenous cells. The 110–150 μm diameter spores have three unornamented spore walls: outer (3-layered), middle (2-layered), and inner (3-layered). The germination shield formed on the outer surface of the inner wall is circular, hyaline to (rarely) light yellow, and has a characteristic coiled, orb-like structure formed by a single lobe that surrounds the initial germ hole and terminally bears one germ tube initiation. This unique germ shield structure easily distinguishes the new species from all other *Scutellospora* species; *S. projecturata*, which forms a similarly coiled germ shield, is differentiated by conspicuous columnar projections on the outer spore wall. *S. pernambucana*, collected from the 'Mata Atlantica' and Caatinga biomes in Pernambuco State and a reforestation area in Maranhão State, appears to be a common fungus in Northeastern Brazil.

Key words — *Gigasporaceae, Glomeromycota, Diversisporales*

Introduction

Arbuscular mycorrhizal fungal species that form spores on bulbous sporogenous cells have been reorganized into four families based on germination structure characteristics and phylogenies generated by independent analyses of 18S and 25S rRNA gene sequences (Oehl et al. 2008). Species with only one spore wall containing a warty inner germinal wall layer remain in the revised family *Gigasporaceae* (Morton & Benny 1990, Oehl et al. 2008), while those producing spores with 2–4 walls and a discrete germination shield on the innermost wall were transferred into three new families: a) species with a yellow-brown to brown germ shield were transferred into the *Dentiscutataceae*, b) species with a multiple-lobed, hyaline to subhyaline germ shield and multiple germ tube initiations were attributed to the *Racocetraceae*, and c) species with a simple, bi-lobed to (rarely) mono-lobed, hyaline to subhyaline germ shield with (1-)2 germ tube initiations were transferred to the *Scutellosporaceae* (Oehl et al. 2008). The newly established *Scutellosporaceae* is mono-generic with *Scutellospora* (Walker & Sanders 1986) as type genus.

A new arbuscular mycorrhizal fungal species was found during diversity studies in Northeastern Brazil in Pernambuco State in a Tropical Atlantic forest fragment and in the Caatinga biome and in Maranhão State in a forest revegetation area. The species that forms spores terminally on sporogenous cells and a unique germination shield on the outer surface of the innermost spore wall is hereafter described under the epithet *Scutellospora pernambucana*.

Material and methods

Soil sampling and culturing of AM fungi

Soils were sampled in a tropical forest fragment (i.e., "Zambana") situated among other native forest fragments and sugarcane plantations near the community of Igarassu, Pernambuco State, Northeastern Brazil. The forest site is located at 07°41'29"–07°43'17"S and 35°00'09"–34°58'38"W (20-110 m above sea level). In December 2007 samples were taken from the rhizospheres (0–20 cm depth) of several native plant species characteristic of the 'Mata Atlantica' tropical forest [e.g., *Coccoloba latifolia* (*Polygonaceae*), *Maytenus* spp. (*Celastraceae*), *Clusia nemorosa* (*Clusiaceae*), *Margaritaria nobilis* (*Euphorbiaceae*), *Guapira* spp. (*Nyctaginaceae*), *Calyptranthes brasiliensis* (*Myrtaceae*), *Alseis pickelii* (*Rubiaceae*), *Pouteria peduncularis* (*Sapotaceae*)]. The pH (H_2O) of the sandy soil (91% sand) was 4.8, and available P (extracted after Mehlich; Nelson et al. 1953) was low (3 mg kg^{-1}).

The spore material was studied from field samples that were also used for pot cultures with *Panicum miliaceum* as host. The pots (300 g) were filled with each soil sample and maintained at the greenhouse of the Department of Mycology, Universidade Federal de Pernambuco, Recife. No host colonization or spore formation has yet been observed.

Morphological analyses

Glomerospores were extracted from field soils by wet sieving (Gerdemann & Nicolson 1963) and sucrose centrifugation (Jenkins 1964). The spores were thereafter mounted in PVLG, PVLG + Melzer's reagent, and in water, respectively (Brundrett et al. 1994). For the species descriptions, the terminology recently applied for other genera of the *Diversisporales* (Oehl & Sieverding 2004, Oehl et al. 2006, Sieverding & Oehl 2006, Palenzuela et al. 2008) were adopted, as well as the terminology of Walker & Sanders (1986) for the germ shield structures. For the spore denomination the terminology proposed by Goto & Maia (2006) was used.

Description of the new species

Scutellospora pernambucana Oehl, D.K Silva, N. Freitas, L.C. Maia, **sp. nov.**

MycoBank MB 512130 FIGS. 1-10

Sporocarpia ignota. Sporae singillatim in solo efformatae anguste adiacetae ad cellulas sporogeneas subterminales vel intercalares, flavae ad bruneo-flavae ad flavo-bruneae, globosae (110–145 µm in diametro) vel subglobosae vel ovales (105–135 × 120–150 µm); sporae tunicis tribus: tunica exterior stratis tribus, in totum 3.5–5.5 µm crassa in aqua, expandens cum pressione (5.5–8.5 µm crassa) vel in PVLG (6.0–)9–14 µm crassa; stratum exterius tunicae exterioris hyalinum, evanescens ad semi-persistens, 1.0–2.1µm crassum; stratum medium laminatum, flavum ad brunneo-flavum, expandens cum pressione in aqua vel in PVLG; stratum interius tunicae exterioris flavum ad brunneo-flavum, subtile, 0.5–1.1 µm crassum; tunica media et tunica interior de novo formantes stratis hyalinibus; tunica media duobus stratis in totum 1.1–2.6(–3.3) µm crassa; tunica interior tribus stratis, 1.7–2.8(–3.5) µm crassa; solo stratum medium tunicae interioris purpureo colorans reagente Melzeri; scutellum germinale coniunctum ad tunicam interiorem, hyalinum vel rarum albo-flavum; circulare vel ovale, 50–80(–90) × 60–80(–94) µm in diametro, cum lobo singulare, orbem formans, generaliter cum depressione singulare germinationis; structurae mycorrhizarum ignotae.

Holotype: 83–8301 (URM No. 79239) from 'Zambana' tropical forest fragment, Usina São José, Igarassu, Pernambuco State, Brazil.

Etymology: *pernambucana* referring to the State in Northeastern Brazil where the new species was found first in two different biomes.

Sporocarp formation — unknown.

Glomerospores are singly formed in soils terminally on a subterminal or intercalary bulbous suspensor cell (= 'sporogenous' cell; FIG. 1). Glomerospores are dark yellow to brown yellow to yellow brown, globose (110–145 µm in diameter) to subglobose (105–135 × 120–150 µm) to rarely oval, and have with three walls: an outer, a middle and an inner wall (OW, MW and IW; FIG. 2).

Outer wall is in total 3.6–5.5 µm thick in water, but expanding under pressure to 5.5–8.5 µm and to (6.0–)9.0–14 µm in PVLG based mountants; OW consists of three layers (FIGS. 3–7): outermost wall layer (OWL1), hyaline to subhyaline to light yellow, evanescent to semi-persistent and about 1.0–2.1 µm thick (FIGS. 3, 4, 7). Under field conditions, OWL1 is sometimes recognized only as fragmented remnants on the spore surface (FIG. 6). The second layer (OWL2) is dark yellow to brown-yellow, 2.0–3.6 µm thick in water, expanding to 5.0–7.5 µm under pressure and to (7.0–)8.5–12.0 µm in PVLG based mountants (FIGS. 1–6); OWL3 is concolorous with OWL2, or slightly lighter in color, thin and flexible (0.5–1.1 µm thick) and usually difficult to observe as closely adherent to laminate OWL2; when separating from OWL2, OWL3 often shows several folds (FIG. 5). None of the layers stain in Melzer's reagent. The straight pore channel at the spore base (about 2.8–5.2 µm broad) is often closed by a plug formed by spore wall material of OWL2, but sometimes appears to be open.

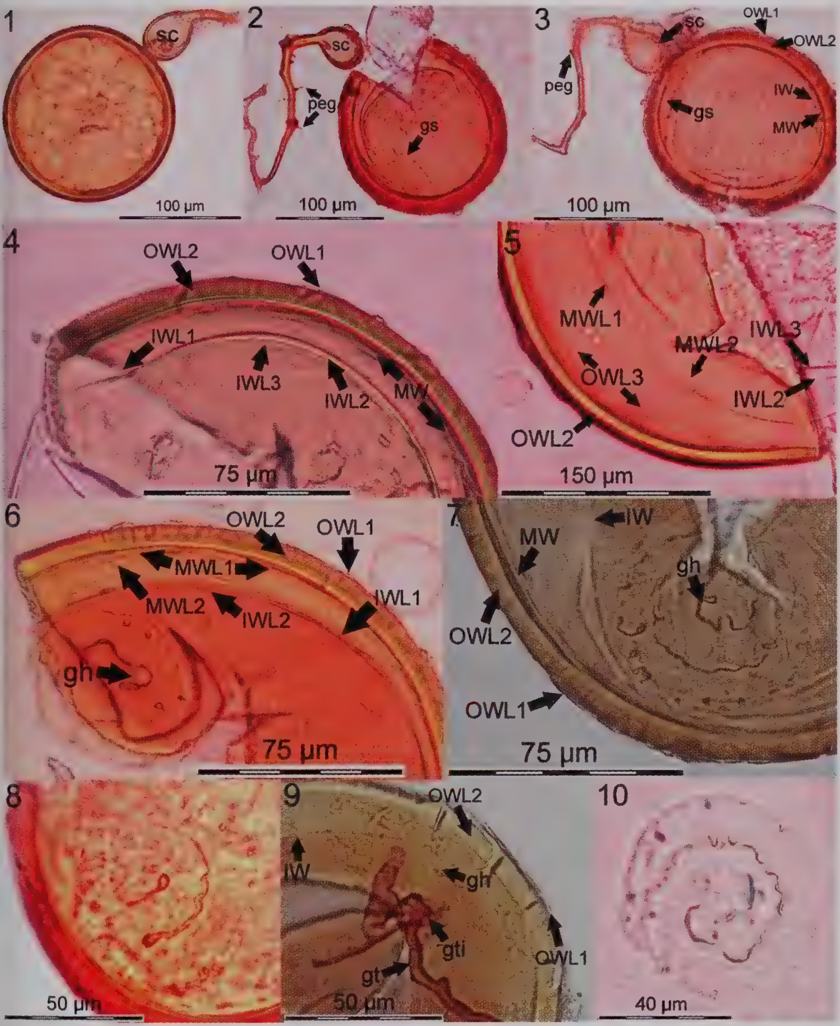
MIDDLE WALL consists of two hyaline, flexible to semi-flexible layers (FIGS. 4–6). Outer layer (MWL1) is about 0.6–1.3 µm thick. Inner layer (MWL2) generally is more rigid as slightly thicker, 1.0–1.5(–2.0) µm. Both layers may slightly expand in PVLG based mountants.

INNER WALL is three-layered (FIG. 4–6) bearing a germination shield on the outer surface (FIGS. 6–7). Outer layer of the inner wall (IWL1) is hyaline, semi-flexible to sometimes finely laminate and 0.4–1.0 µm thick. Second layer (IWL2) is unite to finely laminate, 1.5–2.0(–2.7) µm thick. Innermost layer (IWL3) is thin (0.4–0.8 µm thick), flexible, and — as usually tightly adherent to IWL2 — often difficult to observe. The three layers may slightly expand in PVLG based mountants. Only IWL2 stains in Melzer's reagent become dark red purple within a few hours.

SPOROGENOUS CELL is globose to elongate, concolorous with the spore, or slightly lighter or darker in color, and 31–48 µm long and 26–43 µm broad (FIGS. 1–3). The two wall layers generally visible on the sporogenous cell are continuous with OWL1 and OWL2. OWL1 on the sporogenous cell is about 0.7–1.4 µm and evanescent to semi-persistent; persistent OWL2 is about 2.0–3.5 µm thick. The sporogenous hypha attached is 8–11 µm broad and also bi-layered tapering to 5–7 µm within 200–350(–500) µm distance from the sporogenous cell. The sporogenous hyphal wall is concolorous with the spore wall, or sometimes darker yellow than the spore, and tapers from 1.7–2.8 µm to 0.9–1.5 µm within this distance. Several (3-7) septa originating from the inner layer (OWL2) might be visible in the hypha.

GERMINATION SHIELD is hyaline to subhyaline to rarely light yellow, circular (50–)62–85(–95) µm to subglobose to rarely oval (50–75(–85) × 63–90(–98) µm). Shield with one initial germ hole (gh) in the shield center (FIG. 6-7; and drawings of FIGS. 11–14), and one lobe which surrounds one to two folds the shield center and forms a circular, orb-like shield structure (FIGS. 6–14). One germ tube initiation (gti, 2.2–4.0 µm in diameter) is positioned towards the end of the lobe, from where one to rarely two dark yellow germination tubes emerge during germination and penetrate the middle and the outer wall, and branch in a short distance from the spore (FIG. 9). Shield walls (0.8–1.5 µm thick) often appear sparsely dentate and generally wrinkling (FIGS. 7–10), since the shield wall respective the lobe wall is rather thin, 0.6–1.2 µm.

SPORE DEVELOPMENT — The major spore developmental stages were deduced from clearly identified spores of *S. pernambucana* found in the field samples.


1
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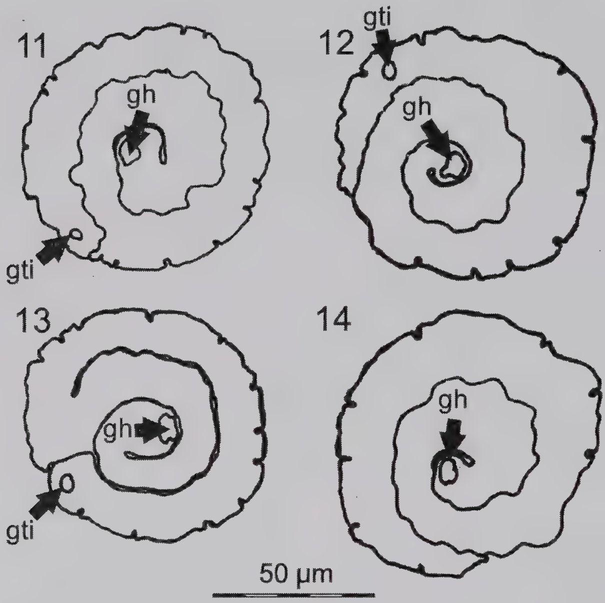
7
IW
MW
gh
OWL2
OWL1
75 µm
8
50 µm
9
OWL2
IW
gh
gti
gt
OWL1
50 µm
10
40 µm

Figs. 1–10: *Scutellospora pernambucana* **Figs. 1–3.** Spores with three spore walls (outer, middle and inner wall; OW, MW, IW), and formed terminally on sporogenous cells (sc). Sporogenous hyphae with several initial, but rudimentary branchings (pegs), and with several septa. **2–3.** Germination shield visible in cross view on the inner wall. **Figs. 3–7.** Spore wall structure with three layered OW (OWL1-3), bi-layered MW (MWL1-2) and three-layered IW (IWL1-3). **Fig. 6.** IWL2 with purple reaction in PVLG + Melzer's reagent. **Figs. 6–10.** Orb-like germination shield formed on the outer surface of IW. The initial germ hole (gh; Fig. 6–7) and the terminal germ tube initiation (gti; Fig. 9) are not easily detectable. **Fig. 8.** Lobe apparently changed growth direction during shield formation, but remained tightly attached to the shield. **Fig. 9.** Germ tube (gt) emerging from the gti. **Fig. 10.** Germination shield isolated from IW.



Figs. 11–14. *Scutellospora pernambucana*: drawings of circular to oval germination shields with a central initial germ holes (gh), single lobes that terminally or subterminally bear one germ tube initiation (gti) from where the germ tubes emerge during germination. On a few spores, the lobes apparently changed the growth direction during shield formation, but remained tightly attached to the shield (Fig. 11). The gti might not be detectable in young, developing spores (Fig. 12).

First the outer spore wall differentiates into one evanescent to semi-persistent outer layer (OWL1), a laminate layer (OWL2), and the adherent thin inner layer (OWL3). The bi-layered middle wall (MW) and (subsequently) the three-layered inner wall (IW) develop de novo without visible connection with the outer wall. Finally, the orb-like germination shield develops on the outer surface of the inner wall.

Auxiliary cells — unknown.

Mycorrhiza formation — unknown.

Distribution — Brazil: so far found in the semi-humid Atlantic Forest or 'Mata Atlantica' biome, in the Municipality of Igarassu and in the Caatinga biome, in the Municipality of Araripina (both in Pernambuco State) and in a Forest regeneration area in São Luis (Maranhão State), suggesting that the new fungus might be common in Northeastern Brazil.

Other specimens or isolates examined: **BRAZIL. Pernambuco State. Igarassu,** Usina São José, Zambana fragment — 83-8302 (URM79240) & 83-8303 (URM79241) deposited in Recife, Brazil; 83–8304 & 83–8305 deposited at OSC (No. OSC# 134503; Corvallis, Oregon, USA); 83–8306 & 83–8307 deposited at Z+ZT (No. ZT Myc 641; Zurich, Switzerland); 83–8308, 83–8309 & 83–8310 (Oehl collection). **Araripina** — specimens deposited at URM. **Maranhão State. São Luis** — specimens deposited at URM.

Discussion

Scutellospora pernambucana can easily be distinguished from all other known species in *Scutellospora* by the spore wall structure and in particular by the unique structure and shape of the mono-lobed germination shield resembling a germination orb. Of all known *Scutellospora* species, only *S. projecturata* forms a similar, mono-lobed, coiled germ shield, but the later species has distinctive, prominent columnar protuberances on the spore surface (Kramadibrata et al. 2000) while *S. pernambucana* has no ornamentation on any of the spore walls. Moreover, the *S. projecturata* shield has a smooth but firm shield wall (FIG. 12 in Kramadibrata et al. 2000), while the thin *S. pernambucana* shield wall is conspicuously wrinkled. The pronounced expansion of the laminate OWL2 in lactic acid-based mountants or under pressure and the evanescent to semi-persistent nature of OWL1, an extremely rare unique feature for *Scutellospora*, are two further helpful diagnostic characters. Observation of these last features is particularly helpful when the shield cannot be observed in planar view or has not yet differentiated in young, developing spores. However, it is also possible that *S. projecturata* has an evanescent outermost wall layer on the surface of the laminated, structural wall layer that was not reported in the protologue. In contrast to the two aforementioned species, most other *Scutellospora* species (e.g. *S. calospora* and *S. pellucida*) have a unit, semi-persistent to persistent layer on the outer surface of the structural, laminate layer (here OWL2), (Koske & Walker 1986).

We interpret the *S. pernambucana* germination shield type as simple-structured and mono-lobed, since obviously only one lobe develops during shield formation. The single lobe surrounds the germ shield initiation, i.e. the initial germ hole (gh; Walker & Sanders 1986) in the shield center. In all shields observed, the lobe surrounded the shield center one to two times and was thus responsible for the characteristic orb-like shield structure (FIGS. 6–14). In a few specimens it appeared that the lobe started to cover the shield center in one direction but obviously changed the direction and thus did not form a typical orb (FIGS. 8, 13). Kramadibrata et al. (2000) described the *S. projecturata* germ shield as coiled but did not refer to the shield structure as an 'orb' or 'orb-like'. In that paper, the illustrated shield of a crushed spore somehow resembles the *S. pernambucana* shield structure presented here in FIG. 13 for, so we assume that the shield structures of both species are indeed closely related.

There are several other *Scutellospora* species with simple and hyaline to subhyaline germ-shields that are, however, bi-lobed (Silva et al. 2006b, Oehl et al. 2008): e.g. *S. calospora* (Koske & Walker 1986), *S. tricalypta* (Ferrer & Herrera 1981), *S. dipapillosa* (Koske & Walker 1985), *S. arenicola* (Koske & Halvorson 1990), and *S. aurigloba* (Walker & Hall 1991). In spores of these species, fully developed shields are violin-shaped, oval to ovoid, or (rarely) cardioid, each generally with one germ tube initiation (gti) on the terminal ends of the two lobes (see Walker & Sanders 1986). Other species such as *S. castanea* (Walker et al. 1993), *S. heterogama* sensu Franke & Morton (1994) and Jeffries et al. (2007), and *S. reticulata* (de Souza et al. 2005) have more complex, multiple-lobed shields with multiple gti or yellow-brown to brown shields that species-specifically may have multiple small compartments and multiple gti, and a conspicuously dentate shield periphery. Such species have been transferred – due to their shield characteristics and for phylogenetic reasons – to newly described genera in the *Racocetraceae* and *Dentiscutaceae* (Oehl et al. 2008).

So far, germination orbs have been described for only a few *Acaulospora* and *Kuklospora* species of the *Acaulosporaceae* (Spain 1992, Sieverding & Oehl 2006) but not for *Scutellospora*. Oehl & Sieverding (2004) did not correctly interpret the circular characteristics of germination orbs (Spain 1992) when they called the *Pacispora* spore germination structures germination orbs. The germination structures in *Pacispora* species generally form first during germination and not, as in *Scutellospora*, during late spore formation, and thus should not be even called shields. Their germ structures are not orb-like but multiple-lobed, and the germ tubes emerge, as in acaulosporoid spores of *Ambispora* (Spain et al. 2006, Goto et al. 2008), from the germination center between the lobes (Oehl unpublished). Interestingly, the germ tubes in the phylogenetically related *Scutellospora*, *Acaulospora* and *Kuklospora* (e.g. Schüßler et al. 2001, Silva et al. 2006a, Palenzuela et al. 2008) emerge from the germ tube initiations positioned at the terminal ends of the lobed germination shields ('gti' in Walker & Sanders 1986, 'germ tube loci' in Spain 1992), and their germination structures generally persist once formed during spore formation. After analyzing recently published phylogenetic trees for *Glomeromycota* species (e.g. Santos et al. 2006, Silva et al. 2006a, Palenzuela et al 2008), we concluded that formation of a persistent germ structure (= germ shield) might be an evolutionary advance in *Scutellospora* and *Acaulospora* over other genera (e.g. *Ambispora* and *Pacispora*) that also form an inner, so-called germinal wall. We further assume that formation of a typical germ orb in *S. pernambucana* like that found in *Kuklospora colombiana* (Spain et al. 1992, Sieverding & Oehl 2006) and *K. kentinensis* (Oehl, pers. obs.) might be ancestral in *Scutellospora*, as is inferred for *K. colombiana* in the *Acaulosporaceae* (e.g. Santos et al. 2006, Palenzuela et al. 2008). This later hypothesis can be tested for *S. pernambucana* only after DNA is extracted from viable spores isolated from the field or – even better –successful pure cultures of the new fungus.

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A new species of *Leucoagaricus* (*Agaricaceae*) from Colombia

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Abstract — A new taxon of *Leucoagaricus* is proposed as *L. amazonicus*. The collection representing this species was collected in the lowlands of the Amazonas Department, Colombia, on a dump produced by ants belonging to *Acromyrmex octospinosus*. The very particular habitat, the small size and dark brown basidiomata that stain yellowish when bruised, the peronate inferior annulus, and the cheilocystidia which are relatively short, capitate and filled with dense brown contents are some of the features of this species.

Key words — *Agaricales*, taxonomy, Amazonia

Introduction

Leucoagaricus Locq. ex Singer belongs to the family *Agaricaceae* (Singer 1986, Vellinga 2004), and has approximately 75 species (Kirk et al. 2001). It is characterized macroscopically by having small to medium size basidiomata with lepiotoid or pluteoid habit that varies from fragile and slender to sturdy and fleshy; a pileus surface that is radially fibrillose, floccose, squamulose to fibrillose-scaly, and rarely granulose; an entire or very short striate margin; a thin or thick context that may or may not stain when bruised; free, rarely collariate lamellae; a central, equal to bulbous stipe, and a membranous, ± persistent, and sometimes moveable annulus. Micromorphologically, the *Leucoagaricus* species have basidiospores with or (more commonly) without a rudimentary, rarely distinctive, germ pore and a metachromatic endosporium; a rather thin, smooth to ornamented spore wall; a regular to trabecular hymenophoral trama;

a variable pileipellis that is either a trichoderm or a cutis of repent and radially arranged hyphae lacking sphaerocytes; pleurocystidia that are sometimes present; abundant cheilocystidia, and absence of clamp connections (Singer 1986, Vellinga 2001).

Leucoagaricus species are saprophytic, growing on soil, wood chips, and sawdust in woods, grasslands, road verges, and dune vegetation. The genus is widely distributed but represented by more species in the subtropical and tropical areas than in cool-temperate regions, and it is absent from artic and alpine areas (Vellinga 2001).

Previous molecular studies (Johnson & Vilgalys 1998, Johnson 1999, Moncalvo et al. 2002, Vellinga 2004) imply that *Leucoagaricus* and *Leucocoprinus* Pat. form a monophyletic clade. However, more systematic studies of tropical species and species cultivated by attine ants are needed to resolve the phylogenetic relationships of this group completely.

In Colombia the genus has been little studied, with only one species, *Leucoagaricus rubrotinctus* (Peck) Singer, a very common terrestrial fungus formally reported (Franco et al. 2000).

Materials and methods

Specimens were collected, documented, photographed, and dried according to Lodge et al. (2004). Color designations follow Kornerup & Wanscher (1983). Line drawings were made with the aid of a drawing tube. All micromorphological structures from a tangential section were measured in 3% KOH. Abbreviations describing the basidiospore size are n = number of spores measured, X = mean length × mean width, Q = length/width ratio.

This study is based on 16 sequences. Genomic DNA was extracted from the fresh Colombian material based on the methods of Silva-Pinhati et al. (2004); other sequences used in the analyses were retrieved from GenBank. The sequences were from: *Leucoagaricus gongylophorus* (Möller) Singer, *L. melanotrichus* (Malençon & Bertault) Trimbach, *Lepiota* cf. *abruptibulba* (PA 156), *Lepiotaceae* sp. (PA 170), *Lepiota* cf. *zamurensis* (PA 415), *Lepiotaceae* sp. (PA 280), *Leucoagaricus meleagris* (Sowerby) Singer, *L. americanus* (Peck) Vellinga, *L. bresadolae* (Schulzer) Bon & Boiffard, and *L. georginae* (W.G. Sm.) Candusso. *Macrolepiota procera* (Scop.) Singer was chosen as the outgroup. GenBank access numbers are given in Fig. 3. The new sequence with the accession number EU940371 was also deposited in GenBank.

Molecular studies were based on the ribosomal DNA region encompassing the internal transcribed spacer 1 (ITS1), the 5.8S gene and the internal transcribed spacer 2 (ITS2) regions. Angle amplicon containing these regions was obtained through a polymerase chain reaction (PCR) with the primers ITS5 and ITS4 (White et al. 1990). Sequencing of strands was performed with an ABI model 377 sequencer (Applied Biosystems, Foster City, CA) using a BigDye™ Terminator Cycle Sequencing Ready Reaction Kit (Applied Biosystems) and with the same primers used for the PCR. The sequences were aligned with Clustal W program (Thompson et al. 1994).

Maximum parsimony analysis of nrITS sequences were performed using PAUP* version 4.0b10 (Swofford 2002). The final alignment had 774 characters of which 231 were parsimonious informative.

One hundred heuristic searches were conducted with random sequence addition and tree bisection-reconnection (TBR) branch-swapping algorithm, collapsing zero-length branches and saving all minimal length trees (MulTrees); gaps were treated as missing. To measure relative support for the resulting clades, 1000 bootstrap replications (Felsenstein 1985) were performed under the fast stepwise addition option. The parsimony analysis resulted in three trees, with a tree length of 518 steps, with a consistency index (CI)= 0.7876 and the retention index (RC) = 0.6683.

Taxonomy

Leucoagaricus amazonicus A. Ortiz & Franco-Mol., **sp. nov.** FIGURES 1–2

MYCOBANK MB 512219, GENBANK EU940371

Species nominate Leucoagaricus amazonicus *descripta est per: singularitatem habitus moris sui in sordio receptaculo speciei Acromyrmex octospinosus, per magnitudinem parvam suam, per adustem colorem basidiocarporum pallorem contrahere quandocumque manu operari est, etiam cheilocistidios perexiqui sunt, cum capitibus atque materie contineretur obscurissumum colorem (similes fabarum coffearum color), et annulus ab infimo peronatus est. Principia priora descripta species Leucoagaricus amazonicus ceteris omnibus speciebus ab ipse genere discernerent.*

ETYMOLOGY: Named for the Colombian Amazonia where this species was found.

HOLOTYPE: **COLOMBIA.** DPTO AMAZONAS: Municipio de Leticia. Parque Natural Nacional Amacayacu, Isla de Mocagua, 3° 49' 51.48" S; 70° 19' 59.58" W, flood plain forest, December 11, 2003, A. Ortiz 58 (**Holotype:** HUA).

PILEUS 3–4 cm in diameter, convex to plano-convex; surface velvety when young to velvety at the center and fibrillose-squamulose toward the margin with age; center, fibrils and squamules dark brown (near 7F8), on a white surface in mature basidiocarps; margin incurved to decurved, eroded. PILEUS CONTEXT 3 mm thick, white, changing to yellowish (4A4) when exposed. Odor and taste not distinctive to slightly sweet. LAMELLAE up to 4 mm broad, white, changing to yellowish (4A4) when bruising, free and remote from stipe, crowded; edge entire, marginate brown (7F8) near at the margin of pileus; lamellulae of different lengths. STIPE 3 cm in length, up to 0.2 cm in diameter near the apex, central, slightly clavate; surface fibrillose-squamulose, concolorous with pileus, annulate. STIPE CONTEXT white, stuffed. ANNULUS inferior, peronate, membranous, thin,

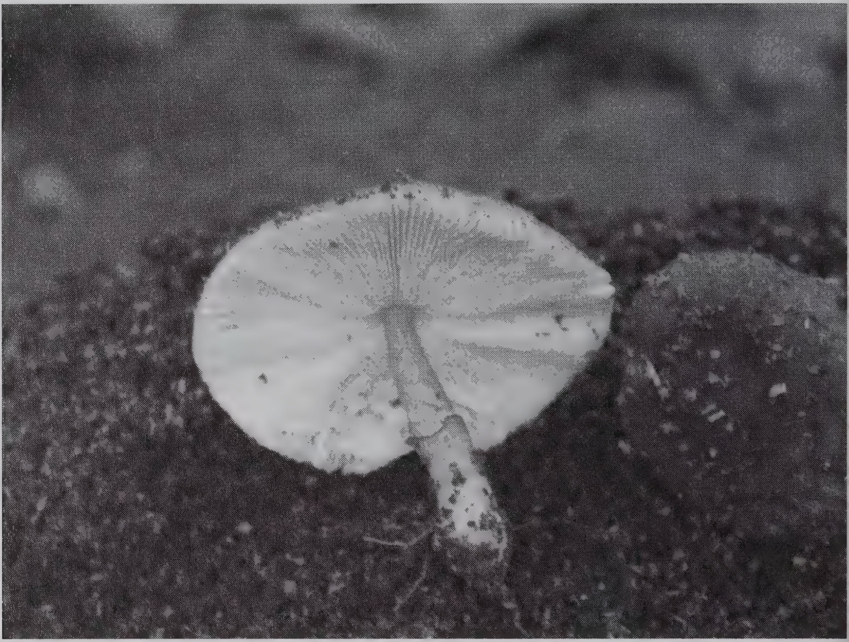

Figure 1. Basidiomata of *Leucoagaricus amazonicus* (Holotype). Photo: Ortiz A.

concolorous with stipe surface but darker at the external edge. Spore print not obtained. Basidiospores (Fig. 2D) 4.0–6.0(–7.0) × (3.0–)3.5–4.0(–5.0) µm, (n = 25; X = 5.12 × 3.98 µm; Q = 1.41 ± 0.03), ellipsoid, amygdaliform, hyaline in KOH, dextrinoid in Melzer's reagent, metachromatic in cresyl blue after a treatment with ammonium and acetic acid, acyanophilic in cotton blue, spore wall smooth and germ pore rudimentary to absent. Basidia (Fig. 2C) 10–15 × 4–6 µm, subcylindric to narrowly clavate, with four sterigmata. Lamellae edge sterile. Cheilocystidia (Fig. 2B) abundant, (15–)20–36(–43) × (8–)10–14 µm, capitate, filled with dense brown content. Pleurocystidia absent. Hymenophoral trama regular, composed of parallel hyphae up to 8 µm in diameter. Subhymenium pseudoparenchymatous and poorly differentiated. Pileipellis (Fig. 2A) a trichoderm of erect, densely crowded, unicellular hairs, up to 126 µm long, and up to 17 µm in diameter, and shorter elements, clavate, broadly clavate to pyriform, thin walled, hyaline, frequently filled with a dense brown content. Pileal trama of interwoven, cylindrical to inflated hyphae, 3.2–12 µm in diameter, thin walled, hyaline, often branched. Stipitipellis composed of vertically oriented and parallel cylindrical hyphae, up to 8 µm in diameter, thin walled, hyaline, giving rise to abundant hairs similar to those of the pileipellis. Clamp connections absent.

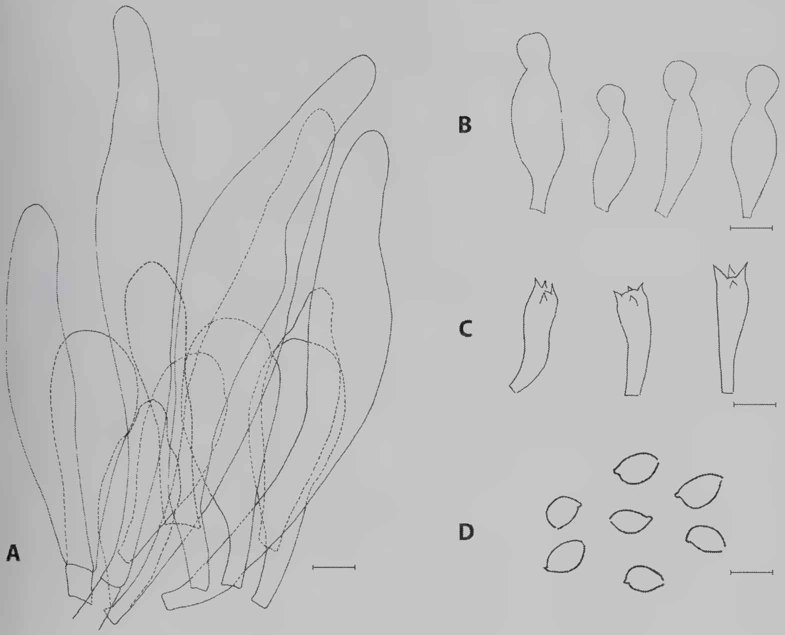

Figure 2. *Leucoagaricus amazonicus*. Microscopic features taken from the holotype. A. Pileipellis elements. B. Cheilocystidia. C. Basidia. D. Basidiospores. Scale bar = 10 μm.

Habitat and distribution – Solitary to dispersed, growing on dumps produced by ants belonging to *Acromyrmex octospinosus* (Reich 1793). These ants build detritus piles away from their gardens and outside of their nest. *Leucoagaricus amazonicus* has been observed only in this habitat.

Discussion

In its habitat, *Leucoagaricus amazonicus* resembles *L. gongylophorus*, from which it differs in the absence of oleiferous hyphae, the presence of short, capitate cheilocystidia filled with brown contents, bigger spores, and smaller basidiomata. Furthermore, while *L. gongylophorus* is cultivated by leaf-cutting ants belonging to *Atta* and *Acromyrmex*, *L. amazonicus* was found on a dump produced by *Acromyrmex octospinosus* (Bononi et al. 1981, Muchovej et al. 1991).

Although *L. amazonicus* basidiospores have a rudimentary to absent germ pore, the white pileus context and white lamellae that yellow on exposure or bruising and the pileus surface that breaks into fibrillose-squamulose scales place this species into section *Annulati* (Fr.) Singer, together with *L. naucinus*

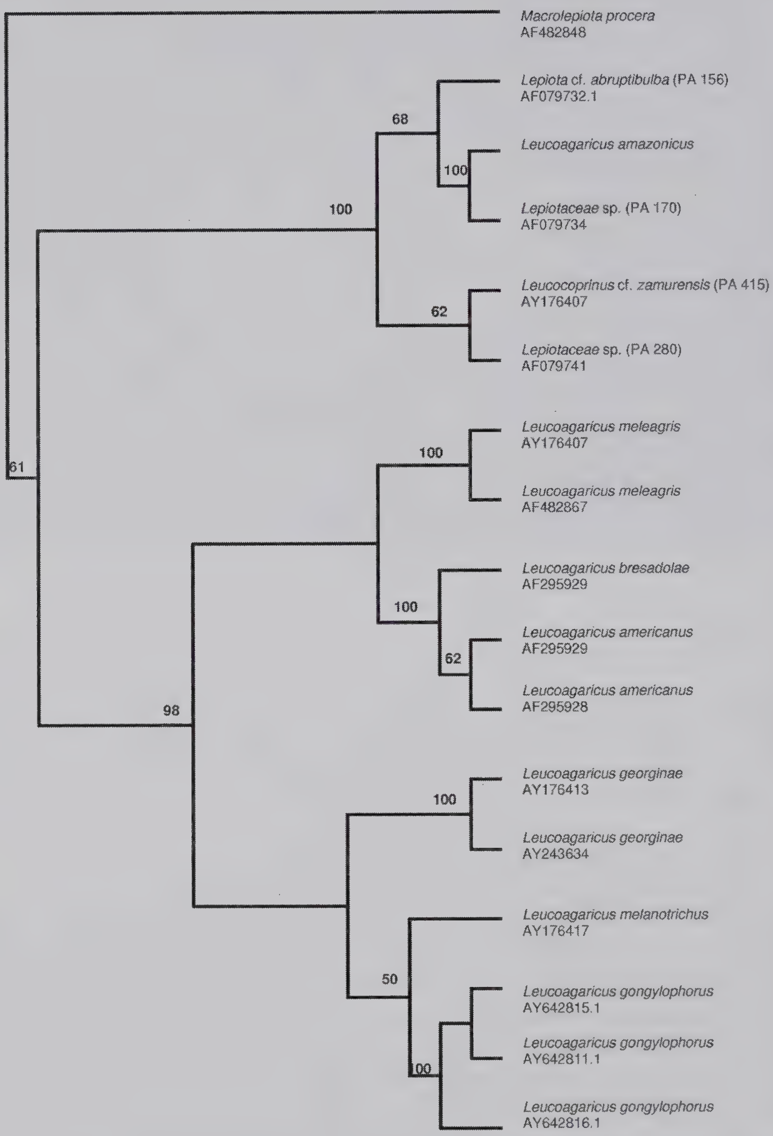
Macrolepiota procera
AF482848
Lepiota cf. abruptibulba (PA 156)
AF079732.1
Leucoagaricus amazonicus
Lepiotaceae sp. (PA 170)
AF079734
Leucocoprinus cf. zamurensis (PA 415)
AY176407
Lepiotaceae sp. (PA 280)
AF079741
Leucoagaricus meleagris
AY176407
Leucoagaricus meleagris
AF482867
Leucoagaricus bresadolae
AF295929
Leucoagaricus americanus
AF295929
Leucoagaricus americanus
AF295928
Leucoagaricus georginae
AY176413
Leucoagaricus georginae
AY243634
Leucoagaricus melanotrichus
AY176417
Leucoagaricus gongylophorus
AY642815.1
Leucoagaricus gongylophorus
AY642811.1
Leucoagaricus gongylophorus
AY642816.1
68
100
100
62
61
100
100
62
98
100
50
100

FIGURE 3. One of the three most parsimonious trees based on nrITS data. Bootstrap values ≥ 50% are given in bold on the branches. GenBank accession numbers are given for each collection.

(Fr.) Singer, *L. leucothites* (Vittad.) Wasser, *L. olgae* (Velen.) M.M. Moser, and *L. gongylophorus* (Singer 1986, Candusso & Lanzoni 1990). However, while *L. amazonicus* grows on ant dumps, the other species in the section grow in grassy areas on disturbed ground or, in the case of *L. gongylophorus,* on ant nests. Microscopically, none of the species in the section combine the characters of *L. amazonicus*, which includes the short and capitate cheilocystidia filled with dense brown contents.

The combination of the colored cheilocystidia, rudimentary to absent germ pore and the yellowing reaction suggest a resemblance to *L. americanus* or similar species such as *L. meleagris* and *Lepiota besseyi* H.V. Sm. & N.S. Weber. However, these species are characterized by having bigger cheilocystidia with a pronounced mucronate apex, and bigger spores with a germ pore (Pegler 1983, Smith & Weber 1987, Vellinga 2000). *L. amazonicus* morphologically resembles some species belonging to section *Piloselli* (Kühner) Singer (Reid 1990), from which it differs by tissues that do not become green in KOH.

Analyses of the ITS data set place *L. amazonicus* with a 100% bootstrap support in a clade with *Lepiota* cf. *abruptibulba* (PA 156), *Lepiotaceae* sp. (PA 170), *Lepiota* cf. *zamurensis* (PA 415), *Lepiotaceae* sp. (PA 280) according to the information obtained from the GenBank (FIG. 3). However, morphological description of these species is not available, limiting our comparison to sequence analyses. A 100% bootstrap supports the clade of *Leucoagaricus amazonicus* and its closest relative, which is an undescribed species cited as *Lepiotaceae* sp. (PA 170) by Mueller et al. (1998). *Leucoagaricus amazonicus* does not cluster with other species with dark brown cheilocystidia, such as those in the *L. americanus* group or with species (such as *L. georginae)* in section *Piloselli.*

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A new species of *Dictyostelium*

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Abstract — A new species, *Dictyostelium culliculosum,* was isolated from forest soil in China. *Dictyostelium culliculosum* is recognized by its special characteristics of cell aggregations and sorophores and bases of sorophores. Detailed descriptions and photographs of important life cycle stages are given based on the holotype.

Key words — dictyostelids, taxonomy

Introduction

The dictyostelids (cellular slime molds) have been known for more than a century. They are often abundant in terrestrial ecosystems. The dictyostelids have both animal-like (protozoan) and plant-like (fungal) characteristics. The vegetative phase consist of small, independent amoeboid cells (myxamoebae) that feed upon bacteria. They stream together in great numbers when the available food becomes exhausted, and form pseudoplasmodia from which subsequently develop sorocarps that consist of stalks and sori. The order *Dictyosteliales* includes four genera, namely *Dictyostelium*, *Polysphondylium*, *Coenonia* and *Acytostelium* (Kirk et al. 2001). The genus *Dictyostelium* was described in 1869 (Raper 1984).

Materials and methods

Fifty samples for isolation of dictyostelids were collected during September 28 to September 29, 2007 in Jilin Province, and deposited under 4 °C condition. The isolation method described by Cavender & Raper (1965) was adopted and improved in this study. Five g of each sample was mixed with 50ml distilled water, and the mixture was shaken for 1–2 h to suspend the cells of dictyostelids. Then 0.5 ml of this suspension and approximately 0.4 ml of a heavy suspension of *Escherichia coli* were added to each of five 95 × 15 mm culture plates prepared with hay infusion agar. Plates were incubated at 23 °C. Each plate was examined once a day following 2 days incubation and then daily for up to 7 days. Isolates were purified and subcultured for taxonomic examination on non-nutrient agar using *E. coli* as the food source. Observations of early aggregations and fruiting bodies were made after 24h of incubation at 23 °C. Sorocarps, stalks and spores were measured, photographed using a Nikon dissecting microscope (SMZ1500) and a Nikon light microscope (SMZ1000).

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*Corresponding author

Taxonomy

Dictyostelium culliculosum Yu Li & Xiao-Lan He, **sp. nov.** FIGURES1, 2

MYCOBANK MB 512298

> *Sorocarpia in agaro non nutricio cum E. coli ad 23 °C plerumque solitaria vel laxe fasciculata, primo erecta vel semi-erecta aut decumbentia, interdum ramosa, rami longi dispersi irregularesque, plerumque 1.2–5.0 mm longa. Sorophora plerumque sinuosa inaequalia, typice e strato cellularum composita vel 2–3-cellulae, segmento terminali leviter caesio vel diaphano, inconspicue angustata e basi ad apicem. Bases conspicuae, geniculatae, multicellulares. Rami sorophorum mediorum superiorumque plerumque e strato cellularum singulo compositi, basibus inconspicuis, plerumque ad angulum rectangulatum ab axe principali abeuntes. Sori globosi vel citriformi, hyalino-albi, plerumque 50–100 μm in diametro. Sporae ellipticae vel oblongae, hyalini, sine polaribus granulis, plerumque 6.2–7.0 × 3.4–4.0 μm. Cellularum aggregationes acervataeque sine rivulis, raro stellatae, producentes unam vel aliquot sorogenam. Sorogena caesia vel schistacea, fortasse sorocarpia formantia in situ vel post motum in distantia brevi. Myxamoebae parvae circa 6–14 × 8–16 μm. Macrocystae globosae, numerus limitatus, plerumque 15–20 μm in diametro; microcystae globosae, numerosae, plerumque 5–9 μm in diametro.*
>
> ETYMOLOGY: Latin, *culliculosum*, referring to the rounded mound-like aggregations.
>
> **Holotype:** MR008. Isolated from forest soil, Wangqing, Jilin Province. Deposited at the Herbarium of the Mycological Institute of Jilin Agricultural University (HMJAU), Changchun.

When cultured at 23 °C on non-nutrient agar with *E. coli*, sorocarps solitary to loosely clustered, erect or semi-erect at first, commonly 1.2–5.0 mm, usually unbranched or with branches limited and spaced irregularly. Sorophores inconspicuously tapering from bases to tips, some typically consist of one tier of cells, and the others are 2–3-celled. Terminal segments of sorophores slightly lavender or translucent. Bases conspicuous, knee-jointed. Branches of middle to upper sorophores generally of one tier of cells, with inconspicuous bases and mostly at a right angle with respect to the main axis. Sori white or colorless, globose or citriform, commonly 50–100 μm in diameter. Spores hyaline, elliptical to oblong, commonly 6.2–7.0 × 3.4–4.0 μm, without polar granules. Cell aggregations typically developing as rounded mounds, usually without stream formation, rarely form star-like shape and with inconspicuous streams at later stage, producing one to several sorogens. Sorogens slightly lavender or

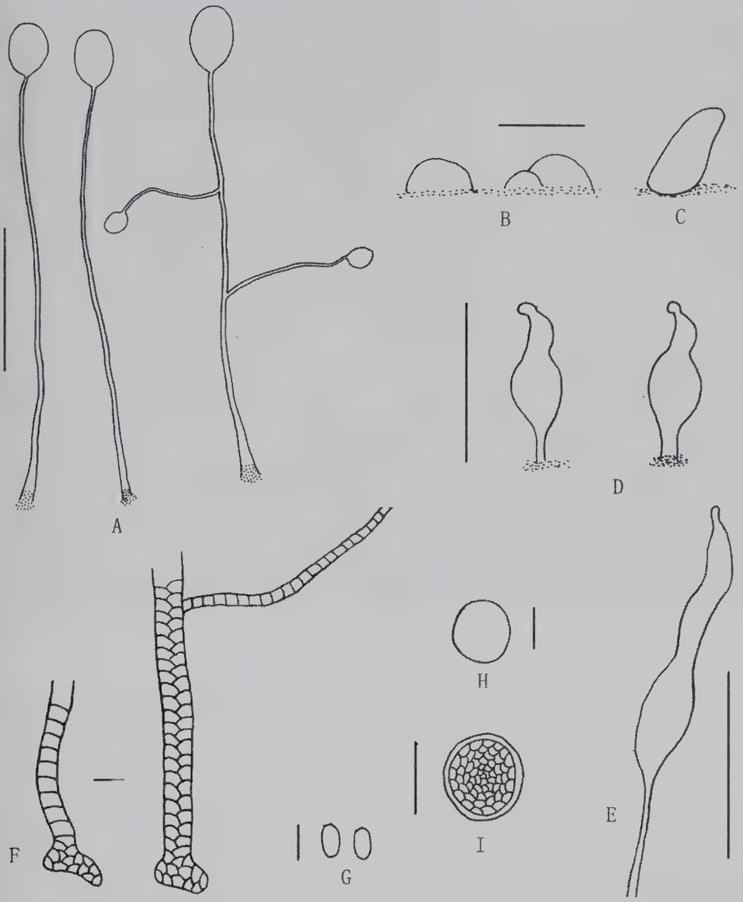

FIGURE 1. *Dictyostelium culliculosum.*

A, Sorocarps; **B**, Aggregation; **C**, Migrating pseudoplasmodium; **D**, **E**, Early (D) and late (E) sorogens; **F**, Sorophores and knee-jointed bases; **G**, Spores without granules; **H**, Microcyst; **I**, Macrocyst. Scale bars: A = 1 mm; B, C = 0.3 mm; D = 0.5 mm; E = 0.5 mm; F = 15 µm; G = 7 µm; H = 5 µm; I = 15 µm.

blue grayish, may fruit in situ or migrate for some distance before sorocarp formation is attempted. Myxamoebae small, about 6–14 × 8–16 µm. Microcysts commonly formed by unaggregated myxamoebae, sometimes dominant in the culture, globose, 5–9 µm in diameter; macrocyst limited in number commonly 15–20 µm in diameter.

COMMENTS: This species can be distinguished from other species of *Dictyostelium* by the combination of the following characteristics: *(1)* mound-

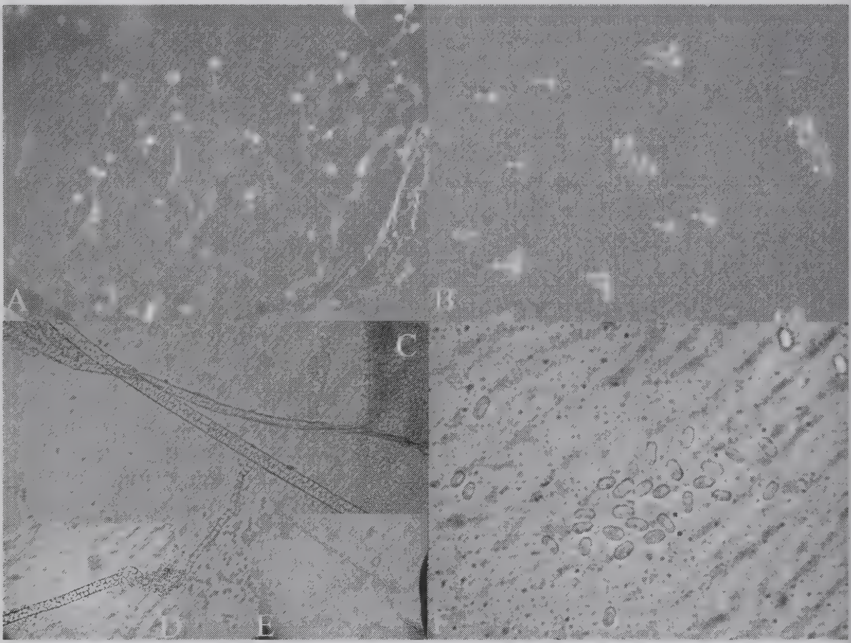

Figure 2. *Dictyostelium culliculosum.*

A, Sorocarps; **B**, Aggregation; **C**, Branch at a right angle with respect to the main axis; **D**, Multicellular sorophore and knee-jointed base; **E**, 1-celled sorophore and knee-jointed base; **F**, Elliptical spores.

like cell aggregations without streams; (2) terminal segments of sorophores slightly lavender; (3) sorogens slightly lavender or blue grayish; (4) bases of sorophores knee-jointed; (5) sorophores consist of 2–3 tiers of cells or typical one tier of cells with knee-jointed bases; (6) sorocarps occasionally branched, lateral branches consist of one tier of cells and mostly at a right angle in respect to the main axis.

Sorocarps of *Dictyostelium culliculosum* closely resemble those of *D. brefeldianum* H. Hagiwara (Hagiwara 1984) and *D. citrinum* Vadell, M.T. Holmes & Cavender (Vadell et al. 1995). However, *D. culliculosum* sorophores lack the capitate tips found in the latter two species. Furthermore, the new species produces mound-like aggregations unlike the radiate aggregations found in *D. brefeldianum* and *D. citrinum*. Lastly, almost all senescent mature sorocarps of *D. culliculosum* lie prostrate on the substrate.

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Records and two new species of *Volvariella* (*Pluteaceae, Agaricales*) from Brazil

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Abstract — Two new species of *Volvariella*, *V. heterospora* and *V. nullicystidiata*, are described and illustrated from specimens collected at the Parque Estadual da Cantareira, São Paulo, SP, Brazil. *V. heterospora* is characterized by its two types of basidiospores, whereas *V. nullicystidiata* lacks cystidia. *Volvariella bombycina* and *V. perciliata*, both collected in the same area, are also described, illustrated and recorded. The latter represents the first record for São Paulo State and the second record for Brazil. In addition, the specimens of *Volvariella* deposited at herbaria SP and collected in remnants of the Atlantic forest of the metropolitan region of São Paulo, SP, Brazil, were re-evaluated.

Key words — *Basidiomycota*, diversity, taxonomy

Introduction

Volvariella Speg. is a widely distributed genus whose species have been reported from tropical, subtropical, and temperate regions of both eastern and western hemispheres (Shaffer 1957). The genus is characterized by bulbangiocarpic development with a membranous or fleshy volva, annulus absent, free and pinkish lamellae, inamyloid basidiospores with a stramineous thickened wall, and bilateral convergent hymenophoral trama (Pegler 1983).

The genus comprises ca. 50 species (Kirk et al. 2001) with 17 mentioned for Brazil. Montagne (1856) was the first author to record species of *Volvariella* from Brazil, with *V. cnemidophora* (Mont.) Singer (as *Agaricus cnemidophorus*). Rick (1930, 1961) recorded eight species of *Volvariella* for Rio Grande do Sul State, viz. *V. bombycina* (as *Volvaria bombycina*), *V. cnemidophora* (as *Volvaria cnemidophora*), *V. fibrillosa* (Bres. ex Rick) Singer (as *Volvaria fibrillosa*), *V. pusilla* (Pers.) Singer (as *Volvaria parvula*), *V. surrecta* (Knapp) Singer (as *Volvaria loveana*), *V. taylorii* (Berk. & Broome) Singer (as *Volvaria taylorii*), *V. thwaitesii* (Hook. f.) G.C. Rath (as *Volvaria thwaitesii*), and *V. volvacea* (Bull.) Singer (as *Volvaria volvacea*).

For Pernambuco State, Batista (1957) described *V. oswaldoi* (Bat.) Putzke (as *Volvaria oswaldoi*) and recorded *V. gloiocephala* (DC.) Boekhout & Enderle (as *Volvaria speciosa*), and later Batista & Bezerra (1960) also mentioned *V. cnemidophora*. Singer (1989) described two new species, *V. macrospora* Singer and *V. rondoniensis* Singer, from Amazonas and Rondônia States respectively. For São Paulo State, *V. bakeri* (Murrill) Shaffer (Grandi et al. 1984, Pegler 1997), *V. bombycina* (Bononi et al. 1981) and *V. taylorii* (Pegler 1997) were mentioned. For Paraná State, ten species of *Volvariella* were mentioned by Meijer (2001, 2006), including *V. bombycina*, *V. earlei* (Murrill) Shaffer, *V. gloiocephala*, *V. hypopithys* (Fr.) M.M. Moser, *V.* cf. *murinella* (Quél.) M.M. Moser, *V. perciliata*, *V.* cf. *pusilla* var. *taylorii* (Berk. & Broome) Boekhout, *V. rondoniensis*, *V.* cf. *striata* N.C. Pathak and *V. volvacea*.

Beside these species, there is the record of three species of *Volvaria* (Fr.) P. Kumm. for Rio Grande do Sul State that were not yet combined in *Volvariella*, viz. *Volvaria pubipes* (Peck) Sacc. (Rick 1938, 1961), *Volvaria rhodomelas* (Lasch) P. Kumm. (Rick 1930, 1938, 1961) and *Volvaria umbonata* var. *brasiliensis* Rick (Rick 1930).

In this article, we report on four species of *Volvariella* recently collected at the Parque Estadual da Cantareira, São Paulo, SP, Brazil, two of which are described as new. In addition, the specimens deposited as *Volvariella* at the Herbário do Estado Maria Eneyda P. Kauffmann Fidalgo (SP) and collected in remnants of Atlantic forest of metropolitan region of São Paulo City, SP, Brazil were also re-evaluated.

Material and methods

The specimens were collected at the Parque Estadual da Cantareira, a remnant of Atlantic forest in São Paulo State, Brazil and deposited at herbarium SP. The macroscopical descriptions and illustrations of basidiomata were based on fresh material. Color terms are from Küppers (1979). The material deposited as *Volvariella* at herbaria SP was revised from herbarium material originally collected at the Parque Estadual das Fontes do Ipiranga (PEFI), a remnant of Atlantic forest inside of urban area of São Paulo City, SP, Brazil. For microscopic analysis, the dried material was rehydrated in 70% ethanol followed by 5% KOH or Melzer's reagent. All microscopic illustrations were made with the aid of a drawing tube. The notation "[a/b/c]" at the beginning of a set of spore data is to be read, "'a' spores were measured from 'b' basidiomata taken from 'c' collections", and the Q represents the range of length/width quotients for all spores measured. The SEM images followed Baroni (1981).

DNA sequences of the large subunit (LSU) and internal transcribed space (ITS) region of nuclear ribosomal DNA were obtained from three species, for future phylogenetic molecular studies. GenBank accession numbers are cited below the species name at the beginning of the formal description.

Results

Three collections deposited as *Volvariella* at SP and collected in Atlantic forest remnants in the metropolitan area of São Paulo City were re-evaluated. Two collections (SP47345 and SP47623) previously identified as *V. bombycina* were destroyed by insects and moulds so that it was impossible to confirm their identifications. Re-examination of the third collection labeled as *V. bakeri* (SP128034) demonstrated that it represents a species of *Pluteus* Fr. section *Pluteus* as indicated by the absence of a volva in the basidioma and presence of horned metuloid cystidia, which is typical of section *Pluteus*. This result invalidated the record of *V. bakeri* for Brazil as mentioned by Grandi et al. (1984) and Pegler (1997).

The other specimens studied in this work collected at the Parque Estadual da Cantareira are described below.

Volvariella bombycina (Schaeff.) Singer FIGS. 1, 5A–B
GENBANK EU920669, EU920673

MACROCHARACTERS — PILEUS large, 140 mm diam., campanulate to convex, slightly umbonate, whitish-cream, surface dry, smooth at center with yellowish fibrils toward the margin. LAMELLAE remote, pinkish, crowded, with lamellulae. STIPE 145 × 11(apex)–17(base) mm, yellowish-cream, tapering toward the apex and slightly bulbous, flexuous, slightly fibrillose at the apex and slightly longitudinally striate toward the base. VOLVA 40 mm long, saccate, yellowish-white, ample, well developed, often deliquescent, with scanty mycelium at the base.

MICROCHARACTERS — BASIDIOSPORES [20/1/1] 8.7(–10) × 6.2(–7.5) µm (Q = 1.33–1.4), ellipsoid, smooth, slightly pinkish, inamyloid, thick-walled, guttulate, often 2-guttulate. BASIDIA (18.7–)20–23(–25) × (6.2–)7.5–8.7 µm, clavate, thin-walled, with small guttulae, 4-spored, with short sterigmata. PLEUROCYSTIDIA (36–)40–64(–70) × (7.5–)8.7–15(–17.5) µm, appendiculate or ventricose, sometimes strangulate at the apex or throughout extension, fairly abundant and well distributed, thin-walled. CHEILOCYSTIDIA (50–)60–94(–100) × (13.7–)16.2–24 µm, clavate to slightly fusoid, very abundant, thin-walled. LAMELLA TRAMA bilateral convergent, 50–89 µm width, of thin-walled hyphae, 3.7–11.2 µm diam., hyaline, sometimes pale yellowish, septate. SUBHYMENIUM cellular. PILEUS CONTEXT undifferentiated, composed by thin-

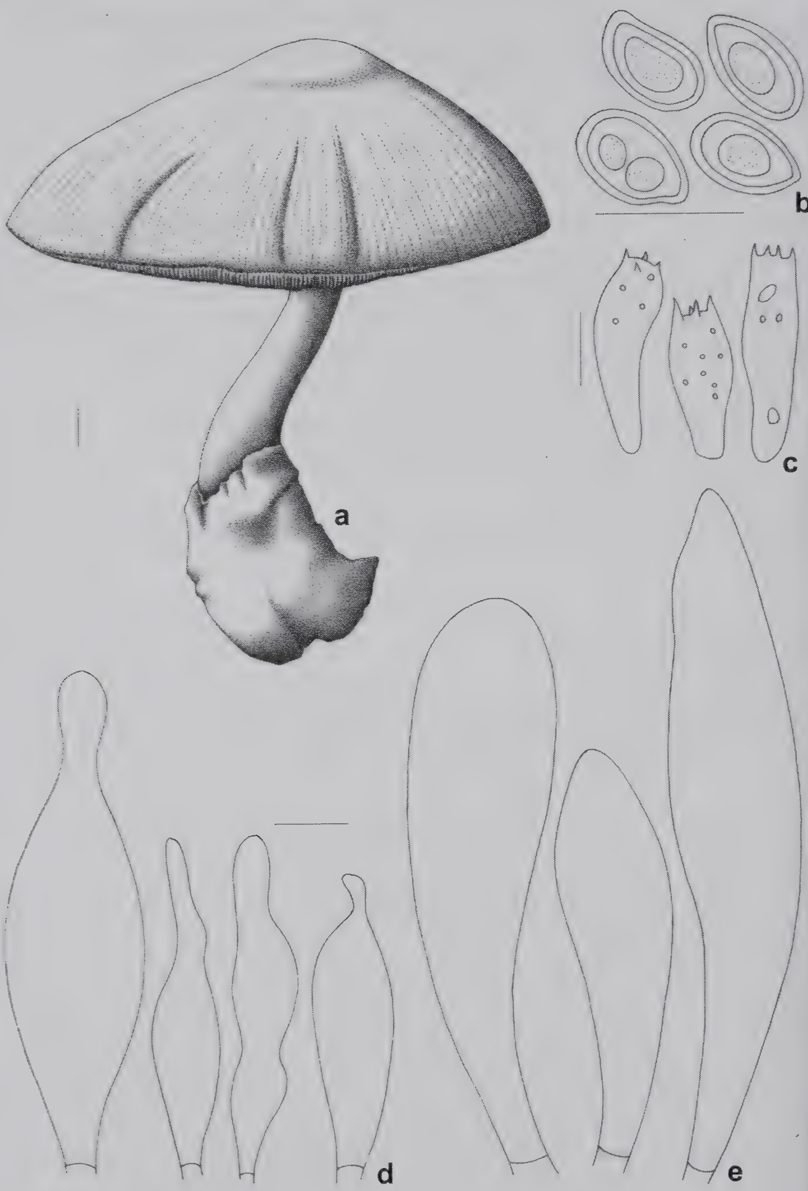


Figure 1: *Volvariella bombycina*. a. Basidioma (Scale bar = 1 cm).
b. Basidiospores. c. Basidia. d. Pleurocystidia. e. Cheilocystidia. Scale bars = 10 µm.

walled hyphae, 6.2–12.5 µm diam., hyaline, septate. PILEIPELLIS composed by thin-walled hyphae, 5–18 µm diam., with yellowish content, arranged more or less parallel to surface. VOLVAL ELEMENTS formed by thin-walled hyphae, 3.7–13.7 µm diam., hyaline or with light brown content, septate, well compacted and parallel. CLAMP CONNECTIONS absent in all parts examined.

HABITAT AND SUBSTRATE — Solitary on decaying wood.

SPECIMENS EXAMINED — **BRAZIL. SÃO PAULO STATE**: São Paulo, PARQUE ESTADUAL DA CANTAREIRA, NÚCLEO ENGORDADOR — 30.X.2007, *Menolli Jr. et al. 151* (SP).

COMMENTS — *Volvariella bombycina* is a widely distributed species and recognized by its robust habit, pale silky-scaly pileus, well-developed saccate volva, habitat on wood, and medium-sized basidiospores. Previous reports of *V. bombycina* from Brazil include Rick (1961) for Rio Grande do Sul State, and in the checklists of Bononi et al. (1981) and Meijer (2001, 2006) from São Paulo and Paraná States respectively.

Volvariella heterospora Menolli & Capelari, **sp. nov.** FIGS. 2, 5C–D

MYCOBANK MB 512149

Pileus 43 mm latus, conicus-convexus, umbonatus, atrocinereus, fibrillosus. Lamellae liberae, roseae. Stipes 68 mm altus, apice usque ad 4 mm latus, basi 8 mm latis, albidus. Volva 170 × 8 mm, adnata vel limbata, alba, externa coacta. Basidiosporae dimorphae: typus I (6.4–)7.2(–8) × (4–)4.8(–5.6) µm, late ellipsoideae vel ellipsoideae, raro elongatus; typus II (8.8–)9.6–12(–13.6) × (4.8–)5.6–6.4 µm, elongatus, raro ellipsoideae, plerumque deformans. Basidia (16.2–)20–21 × 6.2–8.7 µm, clavate, 4-sporigera. Pleurocystidia (32–)37–49 × (6.2–)7.5–10(–11.2) µm, versiformis, appendiculate, ventricosa vel lageniformis, numerosa. Cheilocystidia (26–)34–41(–49) × (5–)7.5–10(–11.2) µm, clavata vel ventricosa. Trama himenophoralis inverse bilateralis, hyaline. Cuticula pilei trichodermate, cellulis terminalis elongates, inflates, erectis vel suberectis. Hyphae omnes defibulatae.

TYPE SPECIMENS — **BRAZIL. SÃO PAULO STATE**: São Paulo, PARQUE ESTADUAL DA CANTAREIRA, NÚCLEO ENGORDADOR — 12.XII.2006, *F. Karstedt & M. Capelari 832* (**HOLOTYPE**-SP).

ETYMOLOGY: the name refers to the different types of basidiospores.

MACROCHARACTERS — PILEUS medium-sized, 43 mm diam., conico-convex, umbonate, dark gray with slightly darker center, surface dry, covered by radially arranged gray fibrils, margin entire, sometimes exposing the lamellae. LAMELLAE free to remote, pinkish, crowded, with lamellulae. STIPE 68 × 4(apex)–8(base) mm, white, tapering towards the apex, slightly subbulbose, surface somewhat pruinose. VOLVA 170 × 8 mm, adnate to limbate, white, well adhered to the stipe, enclosing it like a sock, with a cleavage line at one side of stipe and at another side forming an adhered extension like a limb above the base, outer surface slightly felted.

Microcharacters — Basidiospores [60/1/1] (6.4–)7.2(–8) × (4–)4.8(–5.6) µm (Q = 1.28–1.8), broadly ellipsoid to ellipsoid, rarely elongate, or bigger (8.8–)9.6–12(–13.6) × (4.8–)5.6–6.4 (Q = 1.5–2.43), elongate, rarely ellipsoid, frequently deformed and inequilateral or with the proximal end more tapering than the distal end, smooth, hyaline to slightly pinkish, inamyloid, thick-walled, guttulate, sometimes 2-guttulate, rarely 3-guttulate or nonguttulate. Basidia (16.2–)20–21 × 6.2–8.7 µm, clavate, thin-walled, with small scattered guttulae, 4-spored. Pleurocystidia (32–)37–49 × (6.2–)7.5–10(–11.2) µm, versiform, appendiculate or ventricose, sometimes lageniform 54–62 × 20–22 µm, abundant and sparse, very hyaline and hard to see in KOH, thin-walled. Cheilocystidia (26–)34–41(–49) × (5–)7.5–10(–11.2) µm, clavate to ventricose, not abundant, hyaline and also difficult to see in KOH, thin-walled. Lamella edge heteromorphous. Lamella trama bilateral convergent, 44–50 µm width, of thin or slightly thick-walled hyphae, 2.5–17.5 µm diam., hyaline, septate. Subhymenium cellular. Pileus context undifferentiated, 31–44 µm thick, composed by thin-walled hyphae, 3.7–18.7 µm diam., hyaline, septate. Pileipellis trichodermic, thick, up to 640 µm thick, composed by thin or slightly thick-walled hyphae, 5–26 µm diam., elongated, with terminal elements slightly inflated, septate, with light brown content, arrangement erect or sub-erect. Volval elements formed by thin-walled hyphae, 3.7–7.5 µm diam., hyaline, frequently not septate, interwoven. Clamp connections absent in all parts examined.

Habitat and substrate — Solitary on litter.

Comments — *Volvariella heterospora* is characterized by a small- to medium-sized pileus that is conic-convex, umbonate, and gray with a slightly darker center and by two types of basidiospores, one short, broadly ellipsoid to ellipsoid, and the other bigger, elongate, rarely ellipsoid, and frequently deformed.

This species is similar to *V. murinella*, especially in macroscopic characteristics (Boekhout 1986). But according to this author, *V. murinella* has a low broad umbo, longer basidia [20–30(–35) × 7–10 µm], much longer cystidia [40–100 × 10–30(–50)], uniform basidiospores not exceeding 8.3 µm in length and 4.4 µm in width [or 5 µm according to Orton (1986)]. There is no mention of the two basidiospore types or of the presence of bigger and frequently deformed basidiospores, or of a volval extension along one side of the stipe. Additionally, *V. heterospora* differs in pileus color and shape when compared to the description of *V. murinella* by Lange (1935), who described it as pale ashy gray and convex; Lange's illustration, which was also selected by Boekhout (1986), represents a specimen with totally convex pileus, without evident umbo or conic shape.

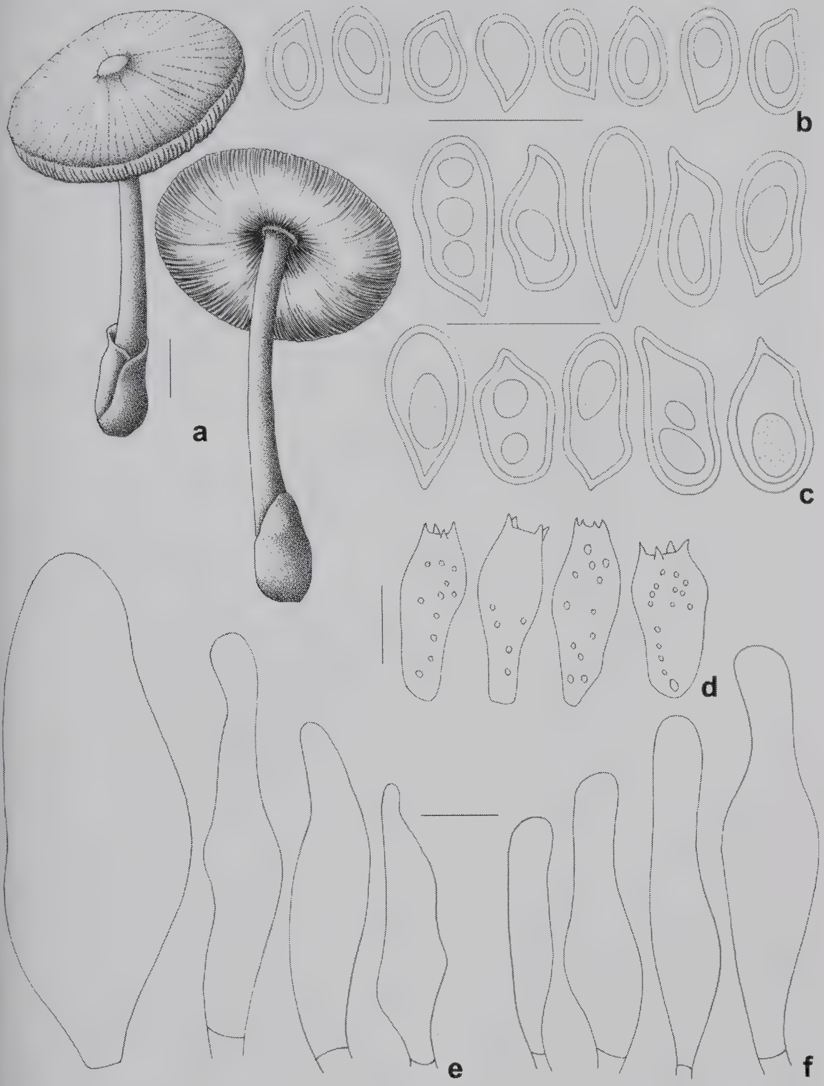


Figure 2: *Volvariella heterospora* (holotype). a. Basidioma (Scale bar = 1 cm). b. Small basidiospores. c. Large basidiospores. d. Basidia. e. Pleurocystidia. f. Cheilocystidia. Scale bars = 10 µm.

Volvariella heterospora also resembles *V. taylorii*, but the latter is differentiated by a gray, gray-olivaceous, hazel, brown, grayish avellaneous or grayish date-brown volva (Lange 1935, Shaffer 1957, Pegler 1983, Orton 1986).

Volvariella nullicystidiata Menolli & Capelari, **sp. nov.** FIGS. 3, 5E–F
MYCOBANK MB 512150; GENBANK EU920670, EU920671

Pileus 66 mm latus, convexus, umbonatus, brunneous, pallidus cinereus ad marginem. Lamellae liberae, roseae. Stipes 108 mm altus, albidus, apice usque ad 4.4 mm latus, basi usque ad 8 mm latis. Volva 28 × 200 mm, saccata, trilobata, cupuliformis, cremeus, cum mycelium basali. Basidiosporae (7.5–)8.7 × (5–)6.2(–7.5) μm, ellipsoideae, raro late ellipsoideae vel ovoideae. Basidia (22–)25–26(–28) × (7.5–)8.7–10(–11.2) μm, clavata, 4-sporigera. Pleurocystidia et cheilocystidia absentibus. Trama hymenophoralis inverse bilateralis, hyalina. Cuticula pilei hyphis repentibus. Hyphae omnes defibulatae.

TYPE SPECIMENS — **BRAZIL. SÃO PAULO STATE:** São Paulo, PARQUE ESTADUAL DA CANTAREIRA, NÚCLEO ENGORDADOR — 31.I.2008, *F. Karstedt et al. 1055* (**HOLOTYPE**-SP).

ETYMOLOGY: the name refers to the total absence of cystidia.

MACROCHARACTERS — PILEUS medium-sized, 66 mm diam., convex umbonate, dark brown at center, discoloring radially towards the margin, margin light gray, surface dry, covered by radially arranged brown-grayish fibrils, margin entire, slightly sulcate. LAMELLAE free, pinkish, with lamellulae. STIPE 108 × 4.4(apex)–8(base) mm, white-cream, light sordid grayish on base, tapering towards the apex, flexuous, slightly longitudinally striate. VOLVA 28 × 20 mm, saccate, beige, cupuliform, firm, well developed, 3-lobate, with cottony mycelium at the base.

MICROCHARACTERS — BASIDIOSPORES [20/1/1] (7.5–)8.7 × (5–)6.2(–7.5) μm (Q = 1.16–1.5), ellipsoid rarely broadly ellipsoid, with the distal end wider and broader than the proximal end (egg-shaped), smooth, slightly pinkish, inamyloid, thick-walled, guttulate, with a small apiculus hard to note and seemingly truncate. BASIDIA (22–)25–26(–28) × (7.5–)8.7–10(–11.2) μm, clavate, thin-walled, sometimes with small guttulae, 4-spored. PLEUROCYSTIDIA and CHEILOCYSTIDIA absent. LAMELLA EDGE fertile. LAMELLA TRAMA bilateral convergent, up to 31 μm width, of thin or slightly thick-walled hyphae, 3.7–15 μm diam., hyaline, septate. PILEUS CONTEXT undifferentiated, approximately 94 μm thick, composed by slightly thick-walled hyphae, 3.7–12.5 μm diam., hyaline, septate. PILEIPELLIS up to 225 μm thick, composed by thin-walled hyphae, 10–30 μm diam., with light brown content, septate, arrangement more or less parallel to the surface.VOLVAL ELEMENTS composed of thin or slightly thick-walled hyphae, 2.5–15(–27) μm diam., some inflated, hyaline, septate, interwoven. CLAMP CONNECTIONS absent in all parts examined.

HABITAT AND SUBSTRATE — Solitary on soil.

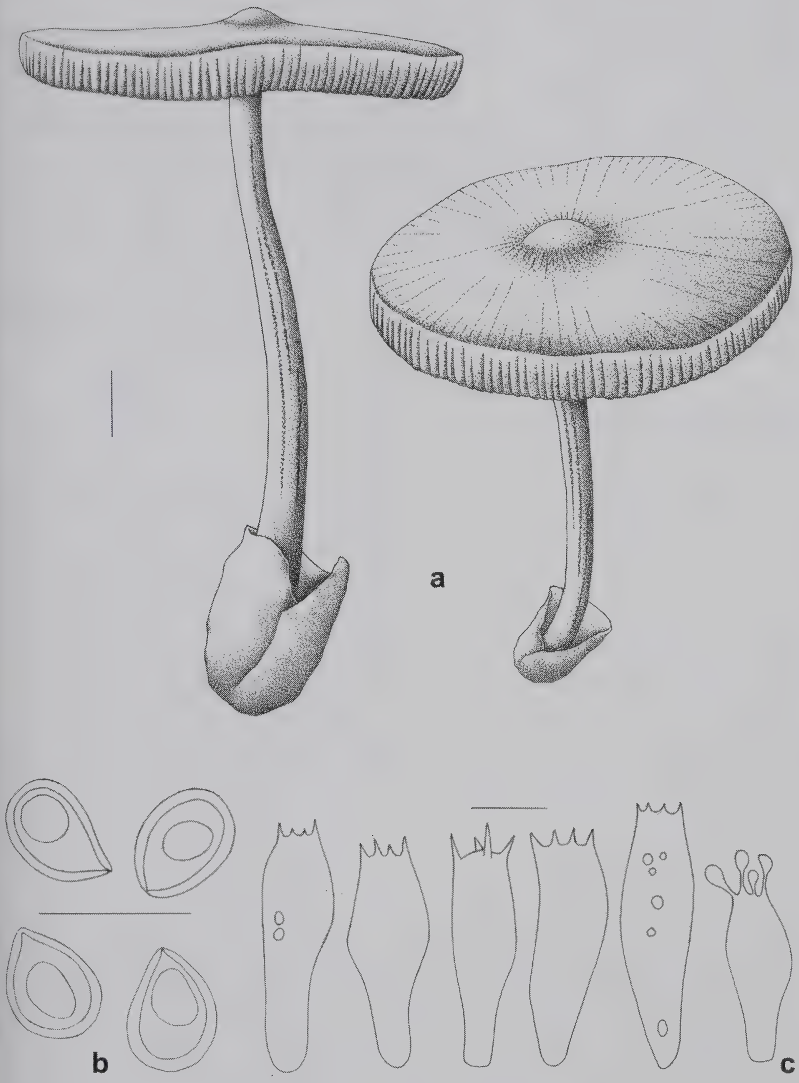


FIGURE 3: *Volvariella nullicystidiata* (holotype). a. basidioma (scale bar = 1 cm). b. basidiospores. c. basidia. scale bars = 10 µm.

Comments — *Volvariella nullicystidiata* is characterized by the complete absence of cystidia. Few species of *Volvariella* lack cystidia, among them are *V. acystidiata* N.C. Pathak and *V. jamaicensis* (Murrill) Shaffer. *Volvariella acystidiata* is quite different from *V. nullicystidiata* because it has basidiospores that are much longer [14.2–17.1(–19.9) × 8.5–10] as described in the protologue (Pathak 1975). In addition, *V. acystidiata* has a narrower (25 mm) cream-colored viscid pileus, white and fragile volva, and basidia that are slightly longer (26.4–37.2 × 14.4–15.6 μm) as described by Mora (1985) from material collected in Mexico. However, *V. nullicystidiata* is closely related to *V. jamaicensis*. The latter differs by the gregarious habit, slightly narrower pileus (50 mm) with slightly granular surface, shorter stipe (50 × 3–5 mm), and a rather delicate, narrow, avellaneous and slightly shorter (10–20 mm) volva as described in the protologue (Murrill 1911). Besides, *V. jamaicensis* has shorter and much narrower basidiospores, which were cited in the protologue as 5 × 3 μm and in the type study by Shaffer (1957) as 6.2–8 × 3.3–4.3 μm with a larger Q value of 1.54–2.08.

Volvariella perciliata Courtec. Figs. 4, 5g–h
GenBank EU920668, EU920671

Macrocharacters — Pileus small, 16–17 mm diam., convex with mammilate umbo, grayish-brown ($N_{70}A_{40}M_{30}$) with a darker center, discoloring radially towards the margin, surface dry, with short fibrils radially arranged, margin ciliate throughout its extension. Lamellae free, pinkish, with lamellulae. Stipe 30–50 × 1.4–2 mm, white, cylindric, slightly pruinose, mostly on apical half, covered by many humidity drops throughout its surface. Volva 5 × 8 mm, saccate, white to slight brownish, firm, like an egg shell, 4-lobate, pubescent.

Microcharacters — Basidiospores [40/2/2] (6.2–)7.5–8.7(–10) × (3.7–)5(–6.2) μm (Q = 1.4–2), ellipsoid to elongate, smooth, inamyloid, thick-walled, guttulate, often 2-guttulate, with a small apiculus hard to note. Basidia (21–)23–29(–31) × (6.2–)7.5–8.7(–10) μm, clavate, thin-walled, with small guttulae, 4-spored, with short sterigmata. Pleurocystidia 47–65 × 6.2–12.5 μm, fusiform occasionally slightly ventricose, sparse, thin-walled. Cheilocystidia abundant, like the pleurocystidia. Lamella trama bilateral convergent, 37–44 μm width, of thin-walled hyphae, 2.5–15 μm diam., hyaline, septate. Subhymenium cellular. Pileus context undifferentiated, approximately 125–187 μm thick, constituted by thin-walled hyphae, 3.7–13.7 μm diam., hyaline, septate. Pileipellis trichodermic, up to 187 μm thick, composed by thin-walled hyphae, 6.2–15 μm diam., elongated with the sub-terminal elements inflated, septate, with light brown content, arrangement erect or sub-erect. Volval elements composed of slightly thick-walled hyphae, 3.7–12.5 μm diam., some slightly inflated, with light brown content, septate, interwoven. Clamp connections absent in all parts examined.

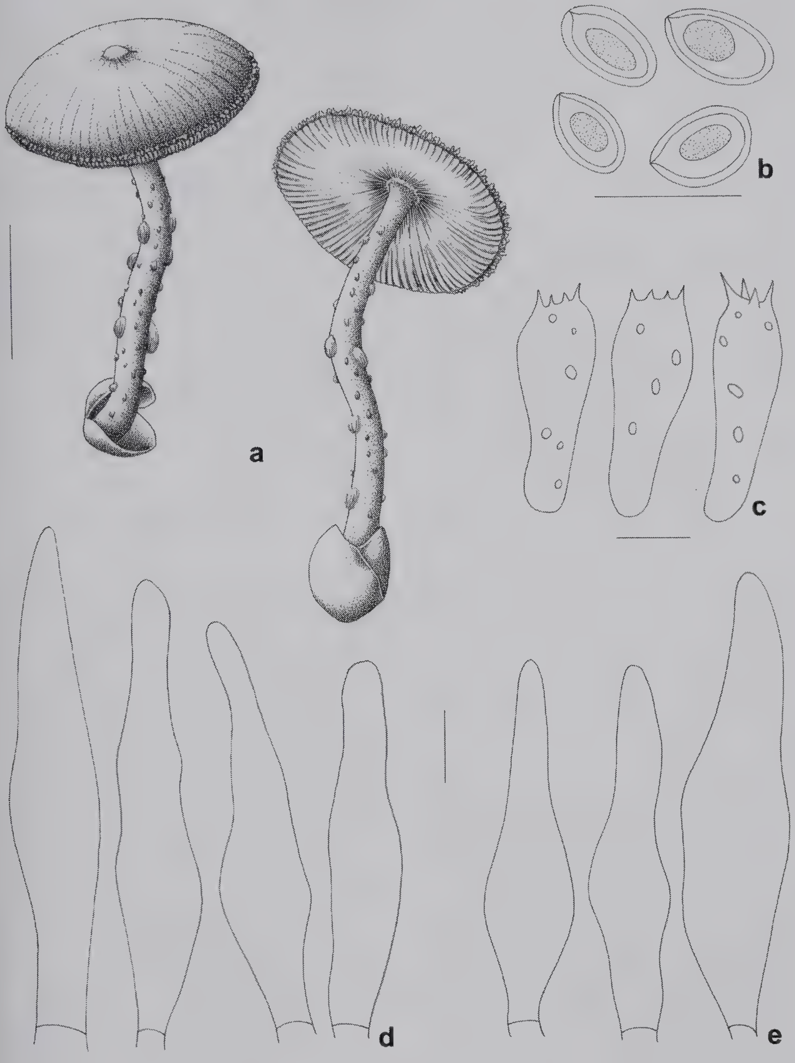
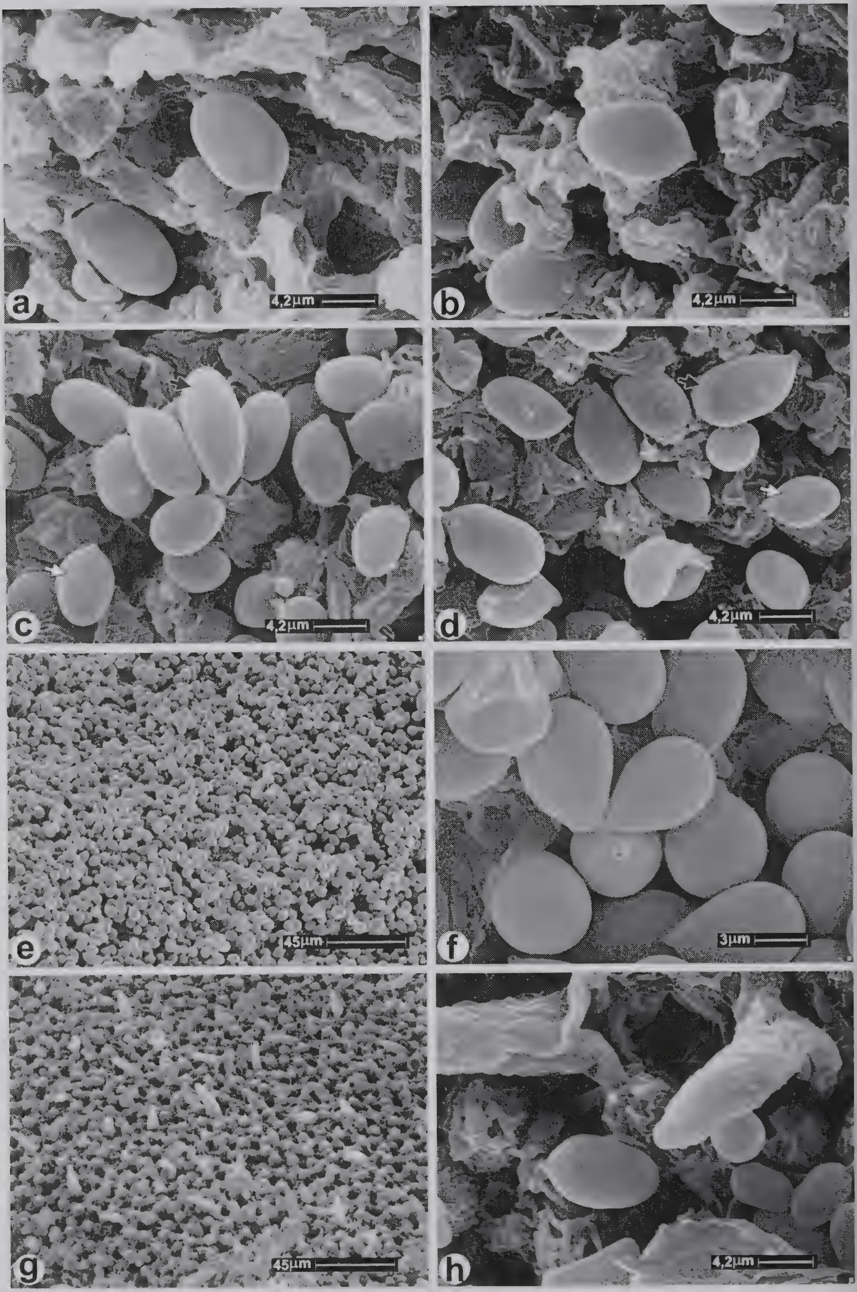


Figure 4: *Volvariella perciliata.*
a. Basidioma with many humidity drops over stipe surface (scale bar = 1 cm).
b. Basidiospores. c. Basidia. d. Pleurocystidia. e. Cheilocystidia. Scale bars = 10 µm.


a
4,2µm
b
4,2µm
c
4,2µm
d
4,2µm
e
45µm
f
3µm
g
45µm
h
4,2µm

Habitat and substrate — Solitary on wood or litter.

Specimens examined — BRAZIL. São Paulo State: São Paulo, PARQUE ESTADUAL DA CANTAREIRA, NÚCLEO ENGORDADOR — 20.III.2007, *Menolli Jr. et al. 115* (SP); 31.I.2008, *F. Karstedt et al. 1051* (SP).

Comments — *Volvariella perciliata* was originally described from French Guyana (Courtecuisse 1991) and is characterized by a small basidioma, a convex grayish-brown pileus with a mammillate umbo and a ciliate margin throughout its extension. The Brazilian specimen has basidiospores that are slightly longer than those described in the protologue (7–8 × 4–4.5 μm) and pleurocystidia slightly shorter than the type (45–75 × 7–12 μm), complying in all other characteristics. Since its original description, this species has been recorded for Paraná State (Meijer 2006). This collection represents the first record for São Paulo State and the second record for Brazil.

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Figure 5: SEM images. a–b. Basidiospores of *Volvariella bombycina*. c–d. Basidiospores of *V. heterospora* (black arrow: large basidiospores; white arrow: small basidiospores). e–f. *V. nullicystidiata*. e. Surface of lamella showing the absence of cystidia. f. Basidiospores. g–h. *V. perciliata*. g. Surface of lamella with numerous pleurocystidia. h. Basidiospores and pleurocystidia.

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A new species of *Ceraceomyces* (*Basidiomycetes*) from India

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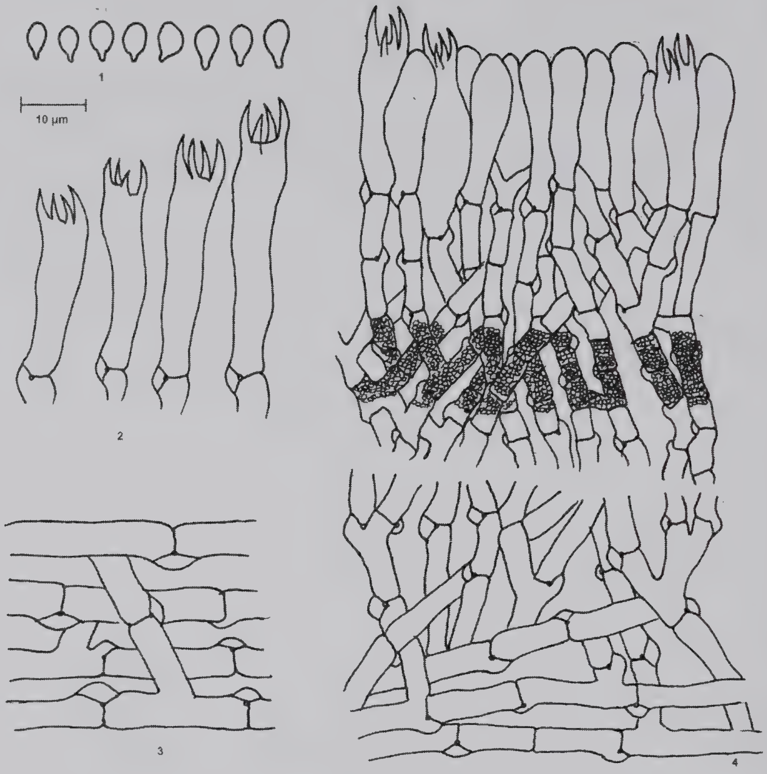
Abstract – A new corticioid species, *Ceraceomyces bizonatus*, is described from Manali hills in Himachal Pradesh.

Key words – Deodar, isodiametric hyphae, Kullu

While exploring the deodar forest in the Kothi area of Manali hills in district Kullu of Himachal Pradesh, India, the authors made a collection on a decaying log of *Cedrus deodara* with ceraceous hymenial surface. After detailed macroscopic and microscopic comparisons with descriptions of known species of genus *Ceraceomyces* (Jülich 1972, Eriksson & Ryvarden 1973, Rattan 1977, Thind & Dhingra 1985, Hjortstam 1998, Larsson & Larsson 1998) we found it to belong to this genus but representing a species of its own. Typical characters for the genus are the ceraceous basidiocarps, clavate, 4-spored basidia with a basal clamp and ellipsoid to somewhat subglobose basidiospores. On the basis of absence of cystidia, it comes closest to *C. microsporus*. However, a two-zoned subhymenium, with a lower zone of vertical hyphae and an upper peculiar zone of short-celled almost isodiametric encrusted hyphae, suggests that it represents a new species. A sample of the basidiocarp was sent to Prof. Nils Hallenberg, University of Göteborg, Sweden, who supported the concept of a new species.

Ceraceomyces bizonatus Dhingra & Avneet P. Singh **sp. nov.** Figs. 1- 5
MycoBank MB507417

Basidiocarpus resupinatus, laxe adnatus, effusus, ad 225 μm crassus in sectionis, membranaceus-ceraceus ad ceraceus; superficies hymenialis laevis ad paulo tuberculatus, fulvus; systema hyphale monomiticum; hyphae ad 4.7 μm latum; basidii 16.5–24 × 3.1–5.5 μm, clavatum, 4-sterigmatum, fibuligerum ad basis; basidiosporii 2.5–3.3 × 1.8–2.2 μm, ellipsoideus ad paulo subglobosum.



Figs.1-4 Microscopic structures from basidiocarp of ***Ceraceomyces bizonatus***
1. Basidiospores; 2. basidia; 3. generative hyphae; 4. vertical section of the basidiocarp.

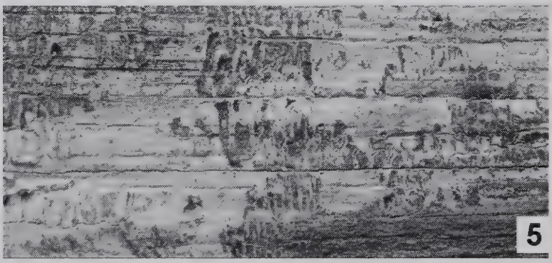


Fig. 5. *Ceraceomyces bizonatus* basidiocarp showing hymenial surface.

Holotypus: *Himachal Pradesh: Kullu, Manali, Kothi,, super truncum* Cedrus deodara, *Avneet 3612 (PUN), Septembre 12, 2004.*

ETYMOLOGY: The epithet refers to the two-zoned subhymenium.

Basidiocarps resupinate, loosely adnate, effused, up to 225 µm thick in section; cracks appear on drying; hymenial surface smooth to somewhat tuberculate, yellowish brown; margins indeterminately thinning. Hyphal system monomitic; generative hyphae up to 3 µm wide, branched septate, clamped, thin-walled; basal hyphae running somewhat parallel to the substratum; subhymenium characteristic in having two zones – lower zone of vertical hyphae without encrustation followed by a peculiar zone of short-celled almost isodiametric, encrusted hyphae. Basidia 16.5–24 × 3.1–5.5 µm, clavate, 4-sterigmate, with a basal clamp; sterigmata upto 3.7 µm long. Basidiospores 2.5–3.3 × 1.8–2.2 µm, ellipsoid to somewhat subglobose, smooth, thin-walled, inamyloid, acyanophilous.

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Annulatascus apiculatus sp. nov., a new freshwater ascomycete from the semi-arid Caatinga biome of Brazil

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Abstract – During an inventory of lignicolous fungi in freshwater habitats in northeastern Brazil, an interesting ascomycete belonging to the genus *Annulatascus* was found. This fungus differs morphologically from other species of *Annulatascus* and is herein described as a new species, *A. apiculatus*. The new species is characterized by globose, black, semi-immersed perithecial ascomata with stout black necks; cylindrical, unitunicate asci that have a relatively large bipartite, refractive apical apparatus; hyaline, 0–3 septate ascospores with short, cellular, hyaline, tapering, bipolar apiculi, and surrounded by a narrow mucilaginous sheath. The new species differs from other described *Annulatascus* species in ascospore dimensions and the presence of bipolar apiculi.

Key words – *Annulatascaceae*, diversity, systematic, submerged wood, taxonomy

Introduction

Aquatic ascomycetes are ecologically important, ubiquitous microbial saprobes in freshwater environments (Wong et al. 1998, Tsui & Hyde 2004, Shearer et al. 2007). About 557 species have been reported from freshwater habitats worldwide (Shearer et al. 2008, http://www.fungi.life.uiuc.edu). It is surprising, therefore, that no species have been reported from Brazil. Absence of such reports most likely reflects lack of collecting efforts rather than absence of these fungi from Brazilian freshwater habitats. To learn more about the freshwater mitosporic and meiosporic ascomycetes in Brazil, we initiated a study of the fungi colonizing dead plant substrates in freshwater habitats in the Caatinga biome in northeastern Brazil.

During this study we collected an undescribed ascomycete from submerged wood in a small stream. This ascomycete strongly resembled species in the *Annulatascaceae (Sordariomycetes)*, particularly those in the genus *Annulatascus*. The most distinctive characteristic of this family and genus is the presence of a very large ascus apical ring. Currently, *Annulatascus* includes 14 species (Tsui et al. 2002). Two of these species, *A. citriosporus* J. Fröhl. & K.D. Hyde and *A. licualae* J. Fröhl. & K.D. Hyde, were described from terrestrial habitats (Fröhlich & Hyde 2000), while most other species have been reported only from freshwater habitats in temperate and tropical latitudes (Hyde & Wong 2000, Cai et al. 2002, Tsui et al. 2002, http://www.fungi.life.uiuc.edu.).

The Brazilian specimen is described and illustrated herein as a new species of *Annulatascus* and is compared to other species in the genus.

Materials and methods

Study site. Collecting trips were made to the Caatinga biome in the Serra da Jibóia, one of nine hygrophilous forests that occur in the semi-arid region in northeast Brazil (Velloso et al. 2002). The vegetation of this area is similar to that of the Atlantic rain forest and has been described previously (Barbosa et al. 2007, Marques et al. 2007). Streams are bordered by bryophytes, pteridophytes and several vascular plants.

Collection techniques. Submerged woody debris was collected from lentic habitats and an unnamed stream in the Serra da Jibóia. Samples of submerged dead plant material were placed in plastic bags and returned to the laboratory. The plant material was then incubated at 25° C in Petri dish moist chambers stored within 50 L plastic boxes with 200 ml sterile water plus 2 ml glycerol. Samples were examined over four weeks for the presence of microfungal fruiting bodies.

Specimen examination. Fruiting structures were located on the substrates with a dissecting microscope and removed to a glass slide where they were crushed and mounted in polyvinyl alcohol-glycerol (8.0 g in 100 ml of water, plus 5 ml of glycerol). Measurements were made of fixed material. Dry material and permanent slides were deposited in Herbarium HUEFS.

Taxonomy

Annulatascus apiculatus F.R. Barbosa & Gusmão, **sp. nov.** FIGS. 1–9

MYCOBANK MB512121

ASCOMATA 400–550 × 240–410 µm, semi-immersa, globosa, nigra, coriacea, aggregata, ostiolata. COLLA 100–250 × 100–180 µm, cylindrica, atro-brunnea, periphysata. PERIDIUM 15–60 µm latis. PARAPHYSES 2.5–6 µm crassae, hyalinae, filiformes, septatae, glabro-tunicatae, simplices. ASCI 175–250 × 10–13 µm, 8-spori, cylindrici, unitunicati, persistenti, pedicellati apparato apicale 6–7.2 × 1.8–2.4 µm. ASCOSPORAE 23–36.5 × 8.8–10 µm, uniseriatae, fusiformes, hyalinae, 0-3 septatae, laevae, cum spinulis in ambibus extremitatibus 0.7–1.2 µm et vagina mucilaginosa circundantes.

HOLOTYPE: HUEFS 134723. **BRAZIL. BAHIA: Santa Terezinha,** Serra da Jibóia, on submerged wood from a stream, 19.II.2008, coll. FR Barbosa.

ETYMOLOGY: Latin, *apiculatus* referring to the apiculus present at both ends of the ascospores.

ASCOMATA on wood, 400–550 × 240–410 µm, clustered, semi-immersed, globose, black, coriaceous, ostiolate. NECK 100–250 × 100–180 µm, cylindrical, dark brown, periphysate. PERIDIUM 15–60 µm wide, dark brown. PARAPHYSES 2.5–6 × 75–100 µm, broad at the base and tapering towards the apex, hyaline, septate, smooth-walled, simple. ASCI 175–250 × 10–13 µm, 8-spored, cylindrical, unitunicate, persistent, pedicellate, with a large bipartite, refractive apical ring, 6–7.2 × 1.8–2.4 µm. ASCOSPORES 23–36.5 × 8.8–10 µm, uniseriate, fusiform, straight, hyaline, 0–3 septate, not constricted at septa, with smooth, short, cellular, hyaline tapering, bipolar apiculi; apiculi 0.7–1.2 µm high; ascospore surrounded by a narrow mucilaginous sheath.

COMMENTS: The presence of an apiculus at both ends of the ascospores of *A. apiculatus* differentiates this species from all other species of *Annulatascus.* The bipolar apiculi on ascospores in the new species is quite different from the bipolar pad-like appendages on ascospores of *A. fusiformis* K.D. Hyde & S.W. Wong (Hyde & Wong 2000). Among the non-appendaged species of *Annulatascus, A. apiculatus* is morphologically most similar to *A. velatisporus* K.D. Hyde and *A. aquaticus* W.H. Ho et al. (Hyde 1992, Ho et al. 1999). However, *A. velatisporus* has larger asci (220–290 × 12–18 µm) and longer non-septate ascospores surrounded by a gelatinous sheath (26–42 µm), while *A. aquaticus* has smaller asci (150–175 µm) and non-septate ascospores with smaller dimensions (19–24 × 6–7 µm). *Annulatascus apiculatus* is also similar to *Annulusmagnus triseptatus* (S.W. Wong et al.) J. Campb. & Shearer in having 3-septate ascospores (Campbell & Shearer 2004). The two species differ, however, in that the ascospores of *A. triseptatus* are almost always 3-septate, while those of *A. apiculatus* are non-septate when young and may become 3-septate when older, and ascospores of *A. triseptatus* are concave or flattened on one side while those of *A. apiculatus* are not. To our knowledge, this represents the first report of a freshwater ascomycete from Brazil.

Acknowledgements

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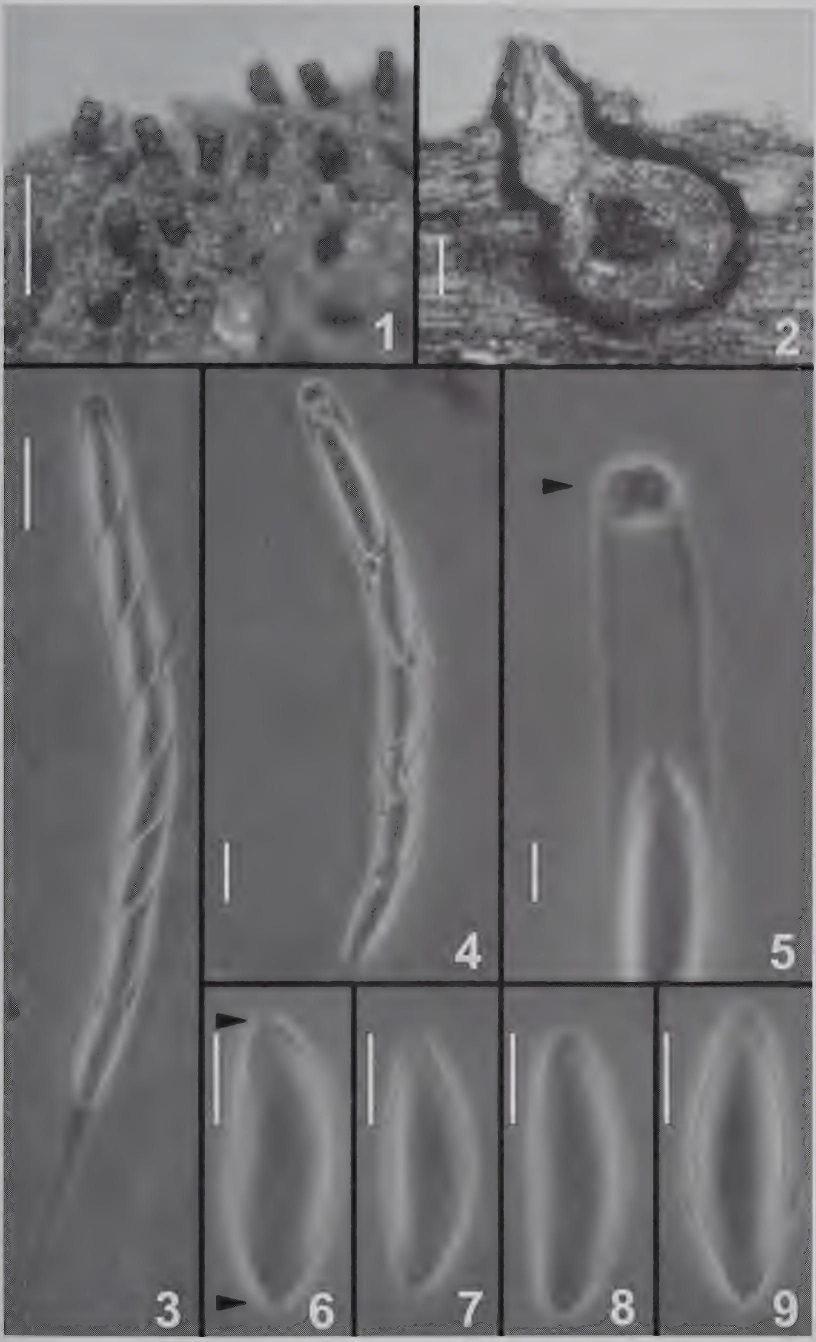
Figs. 1–9. *Annulatascus apiculatus* (from the holotype). 1. Immersed ascomata. 2. Longitudinal section of the ascoma. 3. Ascus with eight ascospores. 4. Older, hyaline septate ascospore in ascus. 5. Ascus apical ring (arrowed). 6–9. Ascospores with bipolar apiculi (arrowed).

Scale bars: 1= 0.5 mm, 2 = 100 μm, 3 = 25 μm, 4 = 15 μm, 5–9 = 10 μm.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Re-identification of the anamorph of *Leuconectria grandis*

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Abstract — The anamorph of *Leuconectria grandis* was previously reported as *Gliocephalotrichum cylindrosporum* based on morphological characteristics. Re-examination of the anamorph and DNA sequence analysis of ITS and β-tubulin indicate that the anamorph of *L. grandis* is distinct from *G. cylindrosporum* and represents an unnamed species of *Gliocephalotrichum*. Following the recommendation of the current International Code of Botanical Nomenclature, we avoid creating a name for the anamorph of *L. grandis*.

Keywords — correction, morphology, taxonomy

Introduction

When the leaf-inhabiting *Leuconectria grandis* (*Nectriaceae, Hypocreales*) was established, its anamorph was described at the same time and treated as *Gliocephalotrichum cylindrosporum* based on morphological characteristics. Distinctions between the *Gliocephalotrichum* material from China (ex type culture of *L. grandis*) and the original description of *G. cylindrosporum* from Thailand (Wiley & Simmons 1971) were discussed and treated as infraspecific variations (Zhuang et al. 2007). Following the recent work on *Gliocephalotrichum* by Decock et al. (2006), it becomes necessary to clarify the taxonomic placement of the anamorph of *L. grandis* based on a combination of morphology and ITS and β-tubulin sequence analysis.

Material and methods

Material used in this study is listed in Table 1. DNA was extracted from the ex-type culture of *Leuconectria grandis*. DNA fragments and primers were selected and DNA amplified in accordance with procedures outlined in Decock et al. (2006). PCR products were purified using 3S Spin PCR Product Purification

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Kit (Shenergy Biocolor for Life Science Co., Ltd.), then sequenced using the same PCR primers with an ABI 3730 DNA analyzer by SinoGenoMax, Ltd. Sequences were analyzed using the package MEGA4.10 (Tamura et al. 2007). The resulting Neighbor-joining tree was derived from analyses of combined sequences of ITS and β-tubulin genes with *Glionectria tenuis* as outgroup.

TABLE 1. Material studied

TAXA	GENBANK NUMBER	
	ITS	β-TUBULIN
Calonectria pauciramosa C.L. Schoch & Crous	AF210886	AY078121
Calonectria pyrochroa (Desm.) Sacc.	AY078115	AY078120
Gliocephalotrichum bacillisporum Decock & Huret 1	DQ374408	DQ374413
Gliocephalotrichum bacillisporum 2	DQ374409	DQ374414
Gliocephalotrichum bulbilium J.J. Ellis & Hesselt. 1	DQ374406	DQ377830
Gliocephalotrichum bulbilium 2	DQ374407	DQ377829
Gliocephalotrichum cylindrosporum B.J. Wiley & E.G. Simmons 1	DQ366705	DQ377841
Gliocephalotrichum cylindrosporum 2	DQ366706	DQ377842
Gliocephalotrichum longibrachium Decock & Charue 1	DQ278422	DQ377835
Gliocephalotrichum longibrachium 2	DQ278421	DQ377836
Gliocephalotrichum microchlamydosporum (J.A. Mey.) B.J.Wiley & E.G. Simmons 1	DQ366700	DQ374411
Gliocephalotrichum microchlamydosporum 2	DQ366701	DQ374412
Gliocephalotrichum ohiense L.H. Huang & J.A. Schmitt	DQ366707	DQ374415
Gliocephalotrichum simplex (J.A. Mey.) B.J. Wiley & E.G.Simmons 1	DQ366703	DQ377839
Gliocephalotrichum simplex 2	DQ366704	DQ377840
Glionectria tenuis Crous & C.L. Schoch	AF220980	AF320194
Leuconectria grandis Y. Nong & W.Y. Zhuang	EF121859	U984072

Results and discussion

Re-examination of the *Leuconectria grandis* anamorph indicates that it differs from any known species of *Gliocephalotrichum* by combining the following features: sterile arms that more or less directly subtend a conidiogenous penicillus in groups of 1–3 with a single arm sometimes growing distantly at the lower portion of conidiophore or occasionally present on both the upper and basal portions; the surface of the sterile arms often covered by an amorphous substance; and narrow-cylindrical conidia that average 8.5–13 × 1.2–1.5 µm. Although the *L. grandis* anamorph more closely resembles *G. cylindrosporum* than any other *Gliocephalotrichum* species with respect to conidial shape and size, the position of the sterile arms is different. Compared to all species producing similarly placed sterile arms, the *L. grandis* anamorph produces narrower, longer conidia that distinguish it (Decock et al. 2006). The anamorph appears to represent an unnamed species of *Gliocephalotrichum*.

To help determine the taxonomic position of the fungus, ITS and β-tubulin gene sequences obtained from the known species of *Gliocephalotrichum* and *L. grandis* were analyzed, and a Neighbor-joining tree was constructed (FIG. 1). Our molecular data indicate that 1) *Gliocephalotrichum* is a monophyletic genus with a relatively high bootstrap support (92%); 2) a sister-group relationship can be recognized within the genus that correlates with the positioning of the sterile arms; 3) *G. cylindrosporum* and *G. simplex* (both producing sterile arms arising at a distance from the conidiogenous penicillus) form one highly (100%) supported group; 4) the remaining species (all producing sterile arms that directly subtend the conidiogenous penicillus) belong to a moderately (73%) supported second group; and 5) there is a very low (42%) bootstrap support for a relationship between *L. grandis* and *G. longibrachium*. Our data clearly indicate that the *L. grandis* anamorph is not conspecific with *G. cylindrosporum* but rather represents a distinct and unnamed species of *Gliocephalotrichum*.

In accordance with the current International Code of Botanical Nomenclature (McNeill et al. 2006: Rec. 59A.3), we do not propose a separate name for the new *Gliocephalotrichum* species. The holomorph name *Leuconectria grandis* adequately designates both teleomorph and anamorph.

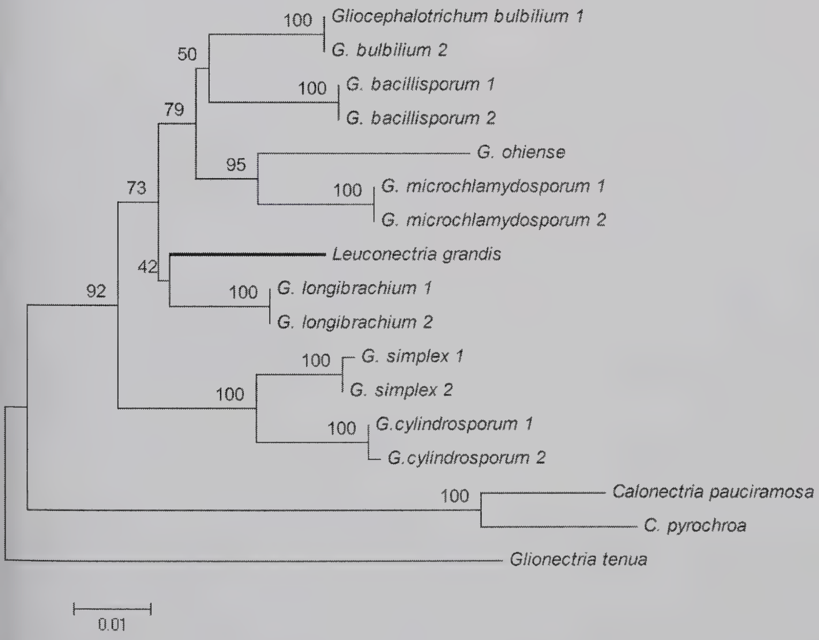
100
Gliocephalotrichum bulbilium 1
G. bulbilium 2
50
100
G. bacillisporum 1
G. bacillisporum 2
79
G. ohiense
95
73
100
G. microchlamydosporum 1
G. microchlamydosporum 2
Leuconectria grandis
42
92
100
G. longibrachium 1
G. longibrachium 2
100
G. simplex 1
G. simplex 2
100
100
G.cylindrosporum 1
G.cylindrosporum 2
100
Calonectria pauciramosa
C. pyrochroa
Glionectria tenua
0.01

FIG. 1 Neighbor-joining tree based on sequence analysis of ITS and β-tubulin genes, showing the relationships among species of the anamorphic genus *Gliocephalotrichum*.

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New species and new Chinese records of *Dothideomycetes*

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Abstract — Some previous and recent collections of bitunicate ascomycetes from China were examined. *Saccardoella psidiicola* is described as a new species. *Dothidotthia ramulicola*, *Macrovalsaria megalospora*, *Phaeosphaeria eustomoides* and *Plowrightia periclymeni* are recorded for the first time from China.

Key words — morphology, taxonomy

Introduction

Patouillard (1886) recorded the first *Dothideomycetes* from China when he described *Leptosphaeria delavayi* Pat. together with six other new fungal species collected by Delavay from Yunnan Province. Later research was attributed to and summarized by Teng (1963), Tai (1979) and Eriksson & Yue (1988). More recently, Wang et al. (1999) and Lu et al. (2000), as well Yuan & Zhao (1994), Hsieh & Chen (1994, 1996), Hyde (1995), Hsieh et al. (1997) and Li & Zhuang (2007, 2008) provided additional records to the Chinese *Dothideomycetes* mycobiota. Some interesting fungi were encountered during our work on the group from tropical and subtropical areas of China. Among them, one new species was discovered and four taxa are recorded for the first time from China.

Material and methods

Herbarium material and recent collections from Hainan, Yunnan and Zhejiang provinces were studied. Ascomata from substrate were rehydrated and sectioned at a thickness of 10–20 μm with a freezing microtome (YD-1508A, Yidi Medical Instrument Co.). Measurements were taken from the sections and from squash mounts in lactophenol cotton blue solution. Photographs were taken using a

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[*] Author for correspondence.

digital camera (Canon G5) connected to a Zeiss Axioskop 2 Plus microscope. The collections studied are deposited in the Mycological Herbarium, Chinese Academy of Sciences (HMAS).

Taxonomy

New species

Saccardoella psidiicola W.Y. Zhuang, W.Y. Li & K.D. Hyde, sp. nov. FIGS 1–5
MYCOBANK MB 512350

Pseudotheciis subglobosis vel piriformebus, 200–365 μm diam., 360–510 μm alt.; ascis clavatis, 8-sporis, 85–124 × 16.5–22 μm; ascosporis fusiformibus, 7–10-septatis, hyalinis, 27–43.5 × 5.3–7.8 μm.

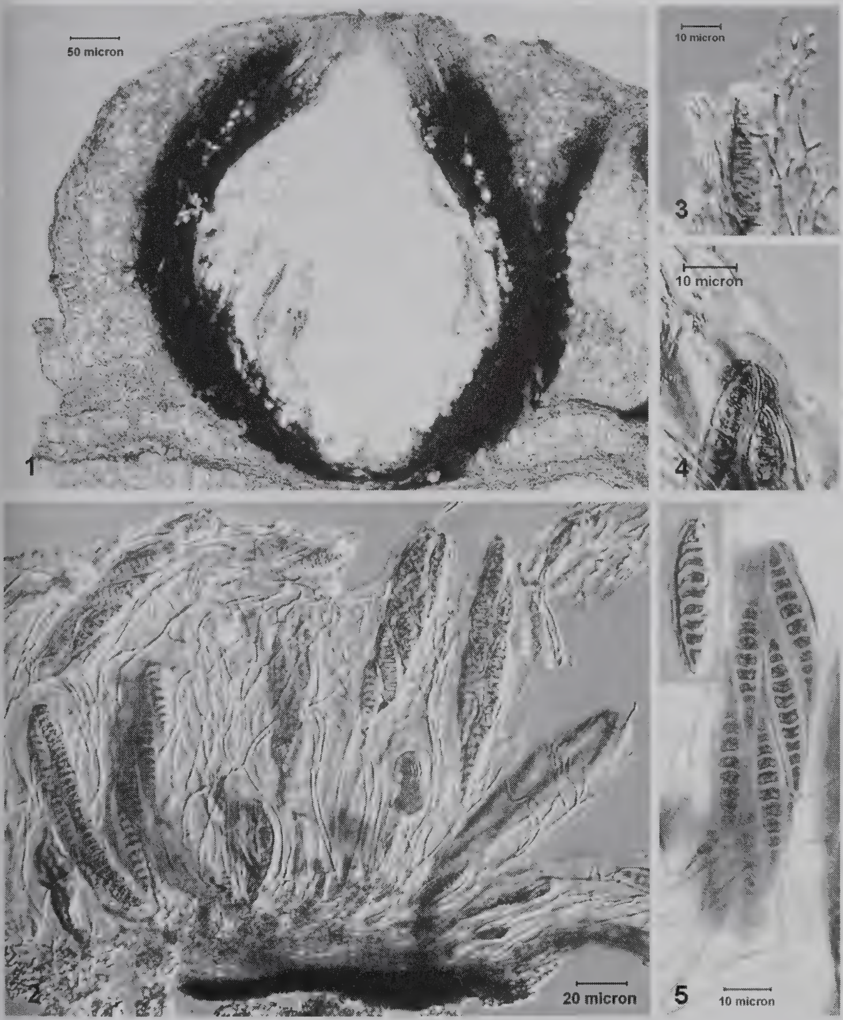
HOLOTYPE: China. Paak Shan, on dead branches of *Psidium guajava* associated with at least four other ascomycetes, V-1919, Otto A. Reinking, HMAS 10708.

ETYMOLOGY: The specific epithet refers to the substrate of the fungus.

Ascomata pseudothecial, subcortical, immersed in a pulvinate stroma, solitary to gregarious, carbonaceous, subspherical to pyriform, individual locules 200–365 μm diam. and 360–510 μm high; hamathecia of trabeculate anastomosing pseudoparaphyses ca 0.8–1 μm wide; asci bitunicate, outer wall very thin, with a thickened apex and a small ocular chamber, apical apparatus absent or unobvious, broadly clavate, 8-spored, 85–124 × 16.5–22 μm; ascospores fusiform, hyaline, surrounded by a thick layer of hyaline gel sheath, mostly 7–10-septate, not constricted at septa, 27–43.5 × 5.3–7.8 μm excluding the sheath, irregularly biseriate to overlapping, spore sheath 1.2–2 μm thick. Anamorph unknown.

NOTES: Among the known species of the genus *Saccardoella* (Spegazzini 1879, Saccardo 1895, 1899, Riedl 1968, Malhotra & Mukerji 1978, Hyde 1992, Mathiassen 1993, Barr 1994, Hsieh et al. 1997, Barr et al. 1998, Tsui et al. 1998, Hyde et al. 2000, Fallah & Shearer 2001, Cai et al. 2002), *S. mangrovei* K.D. Hyde from intertidal mangrove wood is the most similar to the Chinese fungus in ascospore shape and septation, but it differs significantly in fruitbody size (390–845 μm diam., 380–585 μm high), longer and narrower asci (154–216 × 8.5–14 μm) with an apical ring, and shorter spores (26–33 × 6–8 μm) diagonally uniseriate in ascus. *S. graeweana* (Blomb.) M.E. Barr et al. possesses a somewhat similar spore shape, but has narrower asci (75–120 × 8–10 μm) with an apical ring, and narrower spores (30–40 × 3–5.5 μm) with 10–14 septa. The fungus on *Psidium guajava* is new to the genus.

The taxonomic position of *Saccardoella* remains unclear (Eriksson & Hawksworth 1991, Kirk et al. 2001). Because of its thickened ascus apex, small ocular chamber at apical portion of ascus, and trabeculate anastomosing pseudoparaphyses among asci observed in the material, we treat the fungus as a bitunicate ascomycete.



Figs 1–5. *Saccardoella psidiicola* (holotype): **1.** Structure of ascocarp; **2.** Hamathecium, showing clavate asci associated with trabeculate pseudoparaphyses; **3, 4.** Thickening at ascus apex; **5.** Overlapping ascospores in ascus and an ascospore surrounded by a hyaline gel sheath.

New records for China

Dothidotthia ramulicola (Peck) M.E. Barr, Mycotaxon 29: 503, 1987.

≡ *Sphaeria ramulicola* Peck, Ann. Rep. New York State Mus. 25: 104, 1872.

Specimen examined: China. Zhejiang, Tianmushan, alt. 500 m, on dead twigs, 6-XI-2005, W.Y. Li & J. Luo 6785, HMAS 178097.

Notes: Barr (1989) provided a detailed description of this species. The Zhejiang collection is identical with the North American material, especially the red-brown, straight and uniseptate ascospores measuring 19.5–25 × 9.5–14 µm.

Macrovalsaria megalospora (Mont.) Sivan., Trans. Brit. Mycol. Soc. 65: 400, 1975.
≡ *Sphaeria megalospora* Mont., Ann. Sci. Nat., Bot., 2e sér., 14: 324, 1840.
= *Macrovalsaria leonensis* (Deighton) Petr., Sydowia 15: 300, 1962.

Specimens examined: China. Hainan, Sanya, alt. 300 m, on dead twigs, 21-XI-2006, W.Y. Li 7441, 7443, 7447, 7511, HMAS 178153, 178152, 178149, 178150; Hainan, Ledong, alt. 1100 m, on dead twigs, 22-XI-2006, W.Y. Li 7475, HMAS 178151.

Notes: The brown, uniseptate ascospores that are constricted at the septum and the skull cap-like germ apparatus at one end are diagnostic features for the fungus. The genus is monotypic and *Macrovalsaria leonensis* is a synonym (Sivanesan 1975, Hyde et al. 2000).

Phaeosphaeria eustomoides (Sacc.) Shoemaker & C.E. Babc.,
Can. J. Bot. 67: 1526, 1989.
≡ *Leptosphaeria eustomoides* Sacc., Fungi Venet. Nov. Vel. Crit. 2: 319, 1875.

Specimen examined: China. Yunnan, Wenshan, on leaves of *Oryza sativa*, 11-VIII-1938, Q.H. Wang & S.Z. Zhao 6310, HMAS 02310 (filed under *Metasphaeria albescens* Thüm.).

Notes: Our examination indicates that the Yunnan collection is identical with the morphology of *Phaeosphaeria eustomoides* described by Shoemaker & Babcock (1989) based on a collection on *Andropogon ischaemum*.

Plowrightia periclymeni (Fuckel) Sacc., Syll. Fung. 2: 637, 1833.
≡ *Dothidea periclymeni* Fuckel, Jahrb. Nassauischen Vereins Naturk. 23–24: 223, 1870.

Specimen examined: China. Zhejiang, Tianmushan, 1400 m, on small dead twigs of a shrub, 2-XI-2005, W.Y. Li & J. Luo 6695, HMAS 178096.

Diagnostic features: Ascostromata initially immersed, becoming erumpent through the epidermis, pulvinate, with 2–3 locules, 0.5–0.65 × 0.16–017 mm; pseudothecia subglobose, dark brown to nearly black, surface smooth or slightly roughened, 96–226 µm diam., 63–99 µm high; peridium of textura angularis, composed of dark brown, thick-walled cells; asci bitunicate, clavate, 8-spored, 66–96 × 11–14 µm; ascospores fusiform, tapering towards both ends, 1-septate, slightly constricted at septum, hyaline, smooth-walled, irregularly biseriate, 13.5–16.5 × 4.5–5.5 µm.

Notes: The pulvinate ascomata with small locules immersed, bitunicate asci, and hyaline ascospores with one septum indicate its position in the genus *Plowrightia* (Saccardo 1883, 1913, Arx & Müller 1975, Barr 2001). The Chinese collection matches well the original description of *Dothidea periclymeni* on *Lonicera periclymenum* (Fuckel 1870, Saccardo 1833).

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Corticioid fungi (*Basidiomycota*) from Madeira Island

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Abstract — The first catalogue of corticioid fungi from Madeira Island is presented. The study covered 18 localities and 561 samples were analyzed. This catalogue includes 110 species, 89 of them new to the island. They belong to 50 genera, of which *Hyphodontia, Hyphoderma, Trechispora, Stereum, Botryobasidium* and *Sistotrema* are the more significant. The presence of *Stereum pseudorimosum, Subulicystidium perlongisporum* and *Tubulicium dussii* on the island is also remarkable. The complete catalogue is available at http://www.mycotaxon.com/resources/weblist.html.

Key words — *Aphyllophorales*, fungal diversity, lignicolous fungi, Macaronesia, Portugal, species inventory

Introduction

Madeira Island, situated between 32°38' and 32°52' N latitude and 16°39' and 17°16' W longitude, is the largest and highest island of the Madeira archipelago and has a surface of 742 km^2. It is truly volcanic, of Tertiary origin, without connection to any major land masses. Its relief is dominated by Pico Ruivo (1861 m), which divides the island into a North and South part, and Pico do Arieiro (1810 m); the landform is quite complex, characterized by deep ravines and gorges. The coastline is defined by inaccessible high cliffs and abundant caves. The climate includes two main types, mediterranean and temperate with a sharp altitudinal and north-south climatic gradient, with an average annual temperature ranges between 15 to 20 °C and the rainfall ranges from 250 to 750 mm.

The laurisilva is the Macaronesian subtropical mountain moist forest that characterizes Madeira and Canary archipelagos (Jardim & Sequeira 2008). The wildlife of Madeira has been severely affected by human activity. Native timber was heavily exploited over a long period of time, beginning shortly after colonization in the 15th century. The laurisilva, which used to cover most of the Madeira Island, persists now as a relict forest covering 16% of the Island.

Only a few corticioid species have been reported from Madeira (Holl 1830, Torrend 1909, 1912, 1913; Dennis et al. 1977, Dias & Lucas 1980, Calonge & Sequeira 2003, Capelo et al. 2007, Dueñas et al. 2008). These species are specifically mentioned in the catalogue.

Material and methods

18 localities were surveyed over three periods (spring 1998, summer 2000 and autumn 2006). All potential substrates, indigenous and introduced taxa were examined. 561 samples were studied following classical methods: thin, freehand sections were mounted in KOH (5%) and/or Melzer reagent and examined under Olympus BH 50 and Olympus BX 50 microscopes. The specimens have been deposited in BIO, LISU, MA-Fungi, and TFCMic herbaria.

Results

This first catalogue for the corticioid fungi from Madeira Island (http://www.mycotaxon.com/resources/weblist.html.), so far, includes 110 species, of which 89 are new to this island. They represent 50 genera with *Hyphodontia* (10 species), *Hyphoderma* (7 species), *Stereum* (7 species), *Trechispora* (7 species), *Botryobasidium* (6 species), and *Sistotrema* (5 species) being the most significant. The following 89 species are new to Madeira: *Aleurodiscus aurantius* (Pers.) J.Schröt., *Amylostereum laevigatum* (Fr.) Boidin, *Amyloxenasma allantosporum* (Oberw.) Hjortstam & Ryvarden, *Aphanobasidium filicinum* (Bourdot) Jülich, *A. sphaerosporum* Boidin & Gilles, *Athelia decipiens* (Höhn. & Litsch.) J.Erikss., *Athelopsis glaucina* (Bourdot & Galzin) Oberw. ex Parmasto, *Botryobasidium aureum* Parmasto, *B. candicans* J.Erikss., *B. conspersum* J.Erikss., *B. danicum* J.Erikss. & Hjortstam, *B. subcoronatum* (Höhn. & Litsch.) Donk, *B. vagum* (Berk. & M.A.Curtis) D.P.Rogers, *Brevicellicium olivascens* (Bres.) K.H.Larss. & Hjortstam, *Byssomerulius corium* (Pers.) Parmasto, *Cabalodontia queletii* (Bourdot & Galzin) Piątek, *C. subcretacea* (Litsch.) Piątek, *Ceraceomyces eludens* K.H.Larss., *Ceratobasidium cornigerum* (Bourdot) D.P.Rogers, *Coniophora puteana* (Schumach.) P.Karst., *Cylindrobasidium evolvens* (Fr.) Jülich, *Fibrodontia* *gossypina* Parmasto, *Hymenochaete cinnamomea* (Pers.) Bres., *H. corrugata* (Fr.) Lév., *Hyphoderma argillaceum* (Bres.) Donk, *H. definitum* (H.S.Jacks.) Donk, *H. litschaueri* (Burt) J.Erikss. & Å.Strid, *H. medioburiense* (Burt) Donk, *H. occidentale* (D.P.Rogers) Boidin & Gilles, *H. roseocremeum* (Bres.) Donk, *H. transiens* (Bres.) Parmasto, *Hyphodontia alutaria* (Burt) J.Erikss., *H. arguta* (Fr.) J.Erikss., *H. aspera* (Fr.) J.Erikss., *H. bugellensis* (Ces.) J.Erikss., *H. crustosa* (Pers.) J.Erikss., *H. erastii* Saaren. & Kotir., *H. nespori* (Bres.) J.Erikss. & Hjortstam, *H. rimosissima* (Peck) Gilb., *H. spathulata* (Schrad.) Parmasto, *Metulodontia nivea* (P.Karst.) Parmasto, *Mycoacia nothofagi* (G.Cunn.) Ryvarden, *M. uda* (Fr.) Donk, *Peniophora limitata* (Chaillet) Cooke, *P. meridionalis* Boidin, *P. pilatiana* Pouzar & Svrček, *Peniophorella praetermissa* (P.Karst.) K.H.Larss., *Phanerochaete martelliana* (Bres.) J.Erikss. & Ryvarden, *Ph. sordida* (P.Karst.) J.Erikss. & Ryvarden, *Phlebia lilascens* (Bourdot) J.Erikss. & Hjortstam, *Ph. livida* (Pers.) Bres., *Ph. rufa* (Pers.) M.P.Christ., *Ph. subserialis* (Bourdot & Galzin) Donk, *Phlebiella ardosiaca* (Bourdot & Galzin) K.H.Larss. & Hjortstam, *Ph. tulasnelloidea* (Höhn. & Litsch.) Ginns & M.N.L.Lefebvre, *Phlebiopsis ravenelii* (Cooke) Hjortstam, *Pteridomyces bananisporus* Boidin & Gilles, *Radulomyces confluens* (Fr.) M.P.Christ., *Scopuloides hydnoides* (Cooke & Massee) Hjortstam & Ryvarden, *Scytinostroma hemidichophyticum* Pouzar, *Sc. ochroleucum* (Bres. & Torrend) Donk, *Sistotrema brinkmannii* (Bres.) J.Erikss., *S. diademiferum* (Bourdot & Galzin) Donk, *S. hispanicum* M.Dueñas et al., *S. octosporum* (J.Schröt. ex Höhn. & Litsch.) Hallenb., *S. subtrigonospermum* D.P.Rogers, *Sistotremastrum suecicum* Litsch. ex J.Erikss., *Sistotremella perpusilla* Hjortstam, *Steccherinum fimbriatum* (Pers.) J.Erikss., *Stereum ochraceoflavum* (Schwein.) Sacc., *St. pseudorimosum* Boidin & Gilles, *St. rugosum* Pers., *Subulicystidium longisporum* (Pat.) Parmasto, *S. perlongisporum* Boidin & Gilles, *Tomentellopsis echinospora* (Ellis) Hjortstam, *Trechispora alnicola* (Bourdot & Galzin) Liberta, *Tr. cohaerens* (Schwein.) Jülich & Stalpers, *Tr. farinacea* (Pers.) Liberta, *Tr. microspora* (P.Karst.) Liberta, *Tr. minima* K.H.Larss., *Tr. praefocata* (Bourdot & Galzin) Liberta, *Tubulicium dussii* (Pat.) Oberw. ex Jülich, *T. vermiferum* (Bourdot) Oberw. ex Jülich, *Tubulicrinis accedens* (Bourdot & Galzin) Donk, *T. calothrix* (Pat.) Donk, *T. chaetophorus* (Höhn.) Donk, *T. subulatus* (Bourdot & Galzin) Donk, *Xenasma pruinosum* (Pat.) Donk, *X. pulverulentum* (Litsch.) Donk.

A remarkable feature is the presence in the island of *Stereum pseudorimosum*, *Tubulicium dussii* and *Subulicystidium perlongisporum*, species with a similar disjunct geographical pattern.

Finally a Nomina incertae of four names recorded by Torrend (1909, 1912, 1913) that require reevaluation was established.

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Irpex hacksungii sp. nov. (*Polyporaceae*) from Korea

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Abstract — *Irpex* is one of the most common polypore genera and characterized by its poroid to hydnaceous hymenophores, encrusted cystidia, and simple-septate hyphae. An *Irpex* specimen with conspicuous morphological differences from *I. lacteus* and *I. hydnoides* was collected in Korea and this taxon is proposed as a new species, *Irpex hacksungii.*

Key words — *Basidiomycota*, taxonomy, phylogeny, ITS

Introduction

The genus *Irpex* Fr. (*Polyporaceae, Basidiomycetes*) is characterized by its poroid, irpicoid, hydnaceous hymenophores, encrusted cystidia, and simple-septate hyphae (Cejp 1931, Gilbertson & Ryvarden 1986, Ryvarden & Gilbertson 1993). Because of a broad generic concept, the genus *Irpex* included numerous species. However, Maas Geesteranus (1974) treated many *Irpex* species as synonyms of *I. lacteus* (Fr.) Fr. and moved all other species from the genus *Irpex* to other genera. The monotytic genus *Irpex* remained stable then for thirty years (Ryvarden & Gilbertson 1993). Recently, Lim & Jung (2003) included a second species, *Irpex hydnoides* Y.W. Lim & H.S. Jung, in this monotypic genus. *I. hydnoides* is distinguished from *I. lacteus* based on hymenophoral configuration and cultural and molecular characters.

The national biological inventory organized by the National Institute of Biological Resources (NIBR, www.nibr.go.kr) is currently underway and has yielded numerous collections of fungi from Korea. During observations of dry specimens at NIBR, a previously unknown species of *Irpex* was encountered. This fungus is distinct from other *Irpex* species based on morphological and molecular characters. Therefore, it is described in this paper as a new species.

Materials and methods

Specimens and observations

Macroscopic and microscopic characters were based on voucher specimens deposited at Seoul National University Fungi Herbarium (SFC) with duplicates at NIBR. The measurements and drawings were made on slide preparations mounted with 3% (w/v) potassium hydroxide and stained with 1% (w/v) phloxine in water (Largent et al. 1977) using a Nikon microscope and drawing tube.

Molecular analyses

Specimens that used on molecular approaches are listed in TABLE 1. Total DNA was extracted from dried specimens using a Genomic DNA Extraction Kit (Bioneer, Korea). Extracted DNA was stored at –20°C. The internal transcribed spacer (ITS) region was amplified using primers ITS5 and ITS4 (White et al. 1990). PCR amplification was performed as described by Lee et al. (2000). Amplified products were visualized by electrophoresis on a 1% agarose gel, and purified with the PCR purification kit (Bioneer, Korea). Sequencing was performed using the primers described above on an ABI 3730XL automated sequencer (Applied Biosystems, USA). The sequence was proofread, edited, and aligned with other *Irpex* species ITS sequences retrieved from the GenBank using the jPHYDIT program (Jeon et al. 2005). Phylogenetic trees were inferred from sequence alignment using neighbor-joining (NJ), maximum parsimony (MP) and maximum likelihood (ML) methods implemented in PAUP 4.0b10 (Swofford 2002). Likelihood settings were parameterized using the best-fit model (TrN+I) selected by AIC in Modeltest 3.7 (Posada & Crandall 1998).

TABLE 1. *Irpex* specimens used in this study.

SPECIES	VOUCHER NO.	LOCALITY	GENBANK ACC. NO. (ITS)
I. hacksungii	SNU m-990326-16[a]	Korea	EU301650
I. hydnoides	SNU m-971215-19	Korea	AF479667
I. hydnoides	SNU m-971011-12	Korea	AF479668
I. lacteus	SNU m-951007-39	Korea	AF479666
I. lacteus	SNU m-971006-12	Korea	AF163046

[a] SNU, Seoul National University Herbarium, Seoul, Korea, Holotype.

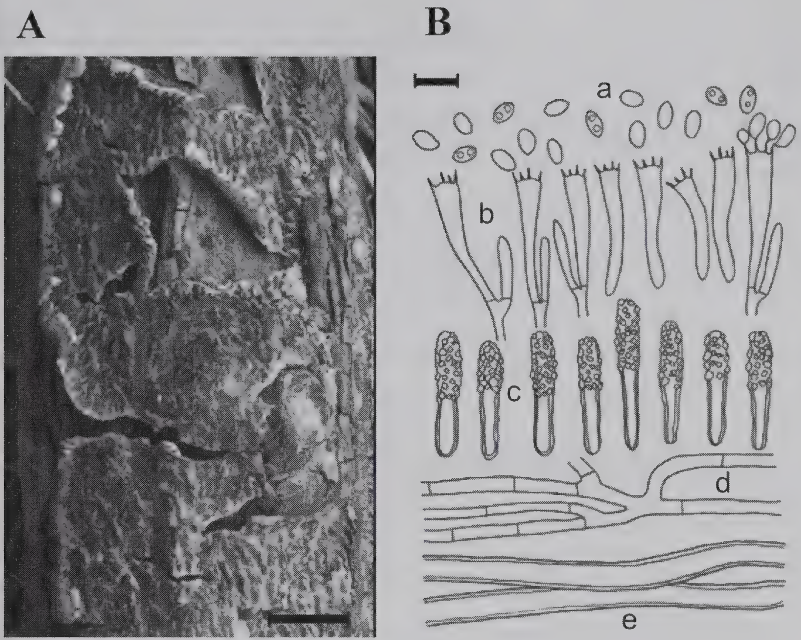

FIGURE 1. Basidiocarps (A) and microscopic features (B) of *Irpex hacksungii* (holotype). a, basidiospores. b, basidia. c, lamprocystidia. d, generative hyphae. e, skeletal hyphae.
Scale bars: A = 5 mm, B = 10 μm.

Results

Taxonomy

Irpex hacksungii J.S. Lee & Y.W. Lim, **sp. nov.** FIGURE 1

MYCOBANK MB 512279

Basidiocarpus annuus, resupinatus vel effuso-reflexus; superficies canus, tomentoso-hirsuto; hymenium cremeo-lutea vel ochraceo, hydnoidea, 2 mm longis; systema hypharum dimiticum; hyphae generatoriae tenuitunicatae, 2–3.5 μm; lamprocystidia incrustata, 24–33 × 5–6.5 μm; basidia clavata, 4-sterigmatibus, 26–32 × 4.5–5.7 μm; basidiosporae ellipsoideae, hyalinae, laeves, non-amyloideae, 5.0–6.2 × 3.0–3.5 μm.

***Holotypus** in herbarium SNU; numero accessiono m-990326-16.*

ETYMOLOGY: "hacksungii", named in honour of Dr. Hack Sung Jung, a pioneering Korean mycologist. Among his many notable contributions to mycological research in Korea were excellent descriptions and keys for identifying polyporoid genera and species.

Basidiocarps annual, usually resupinate or effused-reflexed; pilei protrude up to 3 mm, upper surface light gray; hymenophore cream, ocher to gray, tooth up to 2 mm long; margin loose and often somewhat upcurved. Hyphal system dimitic; generative hyphae thin-walled with frequent branching, frequently septate without clamp connection, 2–3.5 µm wide; skeletal hyphae hyaline, thick-walled, rarely simple septate, 5–6 µm wide. Lamprocystidia abundant, thick-walled, heavily incrusted at apex, 24–33 × 5–6.5 µm, incrusted part 10–14 × 5–6.5 µm. Basidia clavate, 4-sterigmata, 26–32 × 4.5–5.7 µm, simple-septate at the base. Basidiospores elliptical, hyaline, smooth, negative in Melzer's reagent, 5.0–6.2 × 3.0–3.5 µm.

Collections Examined: **KOREA**: Mungyeongsaejae, Mungyeong-si, Gyeongsangbuk-do, on a fallen branch of an unknown deciduous tree, 26 March 1999, Y. W. Lim, deposited in Seoul National University Herbarium (SNU), Specimen No. SNU m-990326-16 (**HOLOTYPE**), and National Institute of Biologial Resources (NIBR), Specimen No. NIBRFG0000001610 (**ISOTYPE**).

Notes – Although this fungus is macroscopically similar to *Irpex hydnoides*, the teeth are shorter and similar to those of *Steccherinum* Gray species. Microscopic differences of *I. hacksungii* include: smaller lamprocystidia than those in *I. hydnoides* and *I. lacteus* (*I. hacksungii*: 24–33 × 5–6.5 µm, *I. hydnoides*: 40–57 × 8–10 µm, *I. lacteus*: 65–80 × 6.8–11.5 µm); smaller basidiospores than *I. hydnoides* (*I. hacksungii*: 5–6.2 × 3–3.5 µm, *I. hydnoides*: 5.9–6.7 × 3.5–4 µm); and smaller basidia than *I. hydnoides* (*I. hacksungii*: 26–32 × 4.5–5.7 µm, *I. hydnoides*: 30–32 × 5.5–6.5 µm) (Table 2).

Table 2. Morphological characters of *Irpex* species.

Species	*Irpex hacksungii*	*Irpex hydnoides*	*Irpex lacteus*
Basidiocarp	Resupinate to effuse-reflexed	Resupinate to effuse-reflexed	Resupinate to effuse-reflexed
Hymenophore	hydnoid, yellow to gray	hydnoid, deep yellow	poroid, irpicoid, hydnoid, milky white to cream
Hyphal system	dimitic	dimitic	dimitic
Lamprocystidia (µm) (encrusted part)	24-33 × 5–6.5 [a] (10–14 × 5–6.5)	40–57 × 8–10 (23–25 × 8–10)	65–80 × 6.8–11.5 (25–31 × 6.8–11.5)
Basidia (µm)	26–32 × 4.5–5.7	30–32 × 5.5–6.5	24–25 × 4–5
Basidiospores (µm)	5–6.2 × 3–3.5	5.9–6.7 × 3.5–4	5.5–6 × 2.2–2.8

[a] Twenty (20) cystidia, basidia and spores of each specimen were measured.

Sequence analyses

The amplified ITS1-5.8S rDNA-ITS2 region of the new *Irpex* species was 594 bp long. There was little intraspecific variation in the ITS region of *I. lacteus* (mean value=0.40%, 0~3/436; 0~3 out of 436 positions showed nucleotide difference) and in the ITS region of *I. hydnoides* (0.46%, 1~5/434). Average sequence variation between *I. hacksungii* and *I. lacteus* or *I. hydnoides* was 3.05% (12~15/433) and 2.88% (12~13/434) respectively. These differences

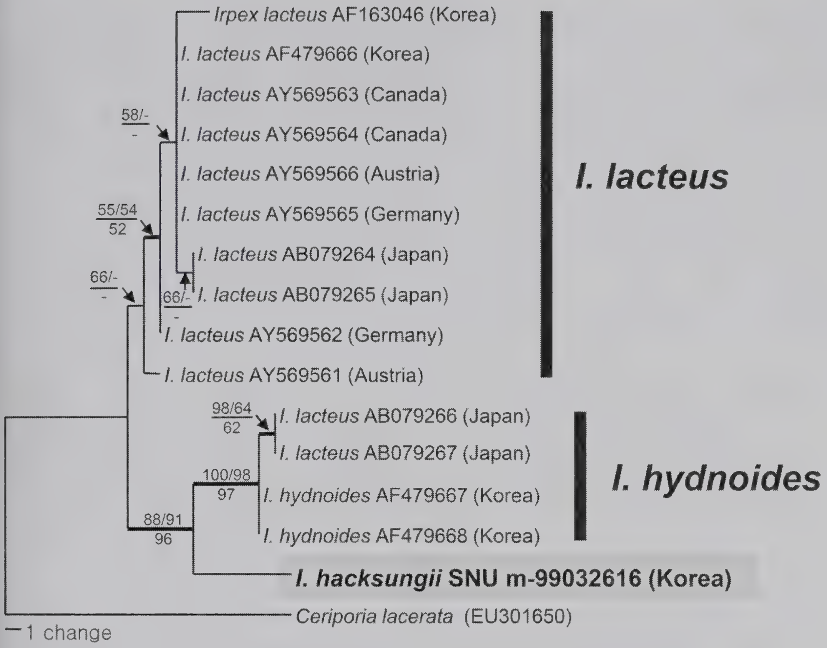
Irpex lacteus AF163046 (Korea)
I. lacteus AF479666 (Korea)
I. lacteus AY569563 (Canada)
58/-
-
I. lacteus AY569564 (Canada)
I. lacteus AY569566 (Austria)
55/54
52
I. lacteus AY569565 (Germany)
I. lacteus AB079264 (Japan)
66/-
-
66/-
-
I. lacteus AB079265 (Japan)
I. lacteus AY569562 (Germany)
I. lacteus AY569561 (Austria)
I. lacteus
98/64
62
I. lacteus AB079266 (Japan)
I. lacteus AB079267 (Japan)
100/98
97
I. hydnoides AF479667 (Korea)
88/91
96
I. hydnoides AF479668 (Korea)
I. hydnoides
I. hacksungii SNU m-99032616 (Korea)
Ceriporia lacerata (EU301650)
1 change

Figure 2. The NJ tree of *Irpex hacksungii, I. lacteus* and *I. hydnoides* based on sequence data of the ITS regions. Branches maintained in three different analyses (MP, ML and NJ analysis) were presented by bold lines. Numbers above branches that are before the slash are NJ bootstrap proportions and those that are after the slash are MP bootstrap proportions. Values below branches are ML bootstrap proportions. The ITS sequence of *Ceriporia lacerata* (EU301650) was used as an outgroup.

are greater than the variation observed between *I. lacteus* and *I. hydnoides* (2.87%, 11~14/433). The aligned sequences of 15 *Irpex* species and *Ceriporia lacerata* N. Maek., Suhara & R. Kondo (outgroup) formed a matrix with 604 nucleotide positions in length. Among these, 554 sites were constant, 38 sites were variable but parsimony-uninformative, and 12 sites were parsimony-informative. NJ, MP, and ML analyses yielded the same phylogenetic trees. The NJ tree is presented in Figure 2. *Ceriporia lacerata* (DQ912694) was selected as an outgroup, as justified in previous phylogenetic study (Lim & Jung 2003). The tree showed that the new *Irpex* species was included in a monophyletic clade with the two other *Irpex* species, *I. lacteus* and *I. hydnoides*. However, its phylogenetic position was distinct within the *Irpex* clade (Fig. 2). Two Japanese *I. lacteus* were grouped into *I. hydnoides*. They might be *I. hydnoides* because i) *I. lacteus* had been treated as a monotypic genus for a long time and ii) *I. hydnoides* was reported only recently (Lim & Jung 2003).

Discussion

Ryvarden (1991) classified the *Polyporaceae* into eleven groups and included *Irpex* in the *Junghuhnia* group along with ten other related genera. However, recent phylogenetic studies using rDNA sequence suggested that the genus *Irpex* showed more relationship with the genera, *Ceraceomyces* Jülich, *Ceriporia* Donk, *Ceriporiopsis* Domański, *Cystidiodontia* Hjortstam, *Hexagonia* Fr. and *Oxyporus* (Bourdot & Galzin) Donk (Ko et al. 2001, Lee 2006). *I. lacteus* and species from the genus *Ceriporia* have received greater attention as they are important white rot fungi due to their production of endo- and exotype cellulases (Hamada et al. 1999, Hoshino et al. 1994), antibiotics and irpexans (Silberborth et al. 2000). They are also capable of decolorizing chemically complex dyes and bioremediation of hazardous organic compounds (Kim & Song 2000, Novotny et al. 2000).

Since Maas Geesteranus's (1974) revision, two species have become accepted in the genus *Irpex*: *I. lacteus* and *I. hydnoides*. We include one more species, *I. hacksungii*, in this genus. Morphological characteristics and phylogenetic analysis of the ITS region show that *I. hacksungii* is closer to *I. hydnoides* than to *I. lacteus*. However, the new species is quite distinct from *I. hydnoides*, because it possesses short teeth, and small lamprocystidia and basidiospores (Table 2). In the molecular phylogenetic analysis, the three *Irpex* species formed a monophyletic clade, but were separated into independent lineages. Additionally *I. lacteus* is distributed worldwide as a cosmopolitan species whereas *I. hydnoides* and *I. hacksungii* appear to be distributed in Far East Asia. *I. hydnoides* was found in China recently (Dai et al. 2008) and Japan (Fig. 2). *I. hydnoides* and *I. hacksungii* might be derived from *I. lacteus* and may have a potential for biotechnological applications, similar to or higher that of *I. lacteus*.

Acknowledgments

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MYCOTAXON

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Parmotrema sanctae-candidae, a new species in the *Parmeliaceae* (lichenized *Ascomycota*) from Brazil

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Abstract — *Parmotrema sanctae-candidae* from Brazil is described as a new species in the *Parmeliaceae*. It is similar to *Parmotrema succinreticulatum* but differs mainly in the presence of marginal to submarginal isidia, which are often apically ciliate and become granular and sorediate. It is so far only known from Paraná state in southern Brazil.

Key words — lichens, *Rimelia*

Introduction

The genus *Parmotrema* A. Massal. includes species that have an upper cortex consisting of a palisade plectenchyma or (rarely) paraplectenchyma with vaults, have a pored or fenestrate epicortex, lack pseudocyphellae, may or may not possess cilia, have laminal, perforate or eperforate apothecia, and usually have simple rhizines and filiform, cylindrical, bacilliform or sublageniform conidia (Blanco et al. 2005). There are 19 species of *Parmotrema* characterized as having a maculate to reticulately cracked upper cortex and rhizines that generally extend to the lobe margins. These species were previously included in the genus *Rimelia* Hale & A. Fletcher.

During a study of the taxonomy and distribution of the *Parmeliaceae* in Paraná State, a new species of *Parmotrema* possessing a maculate to reticulately cracked upper cortex was found. This species is described as new to science based upon its morphological and chemical characteristics.

Materials and methods

The new species was described from specimens collected in the remnants of an Atlantic mixed forest (*Araucaria* forest), a forest typical of southern Brazil. The specimens were examined using standard stereoscopic and light microscopic procedures. Chemical constituents were identified by thin layer chromatography (Culberson & Ammann 1979, Elix & Ernst-Russell 1993) and by comparison with authentic samples.

Taxonomic description

Parmotrema sanctae-candidae Eliasaro, **sp. nov.** FIGURE 1

MYCOBANK MB 512333

Thallus chloroleucus, membranaceus, laxe adnatus, ad corticem arborum, usque 6 cm diametri. Lobi irregulari, superpositi laterale, 3.0–8.0 mm latae, apex rotundus, margines integrae, crenatae ad laciniatas, laciniae ascendentes, breves; cilia moderate densa, nigra, praecipue simplex, 0.5–2.5 mm longitudinis. Superficies superna levis, notate maculata reticulata, aliquando pruinosa alba in apicem loborum. Isidia marginalia ad submarginalia in breves lacinias marginales, brevia, cilindrica, usque 0.5 mm altitudinis, apex cataneus saepe ciliatus, convertus in granulatum sorediosum. Medulla alba. Superficies infera nigra, polita, levis; margo castanea atra aut aliquando variata eboris in lacinulas cum propaginibus, 1–2 mm diametri, levis, polita, rhizinata usque marginem aut margo papillata; rhizinae nigrae, praecipue simplex ad rare squarrosas, 0.1–3.0 mm, abundantes, similiter sparsae. Apothecia et pycnidia ignota. Atranorinam, acidum fumarprotocetraricum et acidum succinprotocetraricum continens.

TYPE: **BRAZIL. PARANÁ: General Carneiro**. FAZENDA SANTA CÂNDIDA, 30.X.2004, *S Eliasaro 2798* (**HOLOTYPE**-UPCB).

ETYMOLOGY: From Sancta Cândida, the place of origin of the type material.

Thallus greenish grey, membranaceous, loosely adnate, corticolous, up to 6 cm wide. Lobes irregularly branched, overlapping laterally, 3.0–8.0 mm wide, apices rounded, margins entire, crenate to sublaciniate; cilia moderately dense, black, simple, 0.5–2.5 mm long. Upper surface smooth, dull, strongly reticulately maculate, sometimes pruinose towards the tips. Isidia marginal to submarginal on short marginal laciniae, short-cylindrical, up to 0.5 mm long, brown-tipped often apically ciliate, ultimately becoming granular and sorediate. Medulla white. Lower surface black, glossy, smooth; marginal zone dark brown or sometimes mottled ivory below the isidiate laciniae, 1–2 mm wide, rhizinate to the margin or with a papillate zone along the margins; rhizines black, simple to rarely squarrose, 0.1–3.0 mm long. Apothecia and pycnidia not seen.

CHEMISTRY: cortex: K+ yellow (atranorin); medulla: K+ faint yellow turning brown, C–, KC+ faint yellow, P+ orange, UV– (succinprotocetraric and fumarprotocetraric acids).

ADDITIONAL SPECIMENS EXAMINED – **BRAZIL. PARANÁ: General Carneiro**. FAZENDA SANTA CÂNDIDA, 30.X.2004, *S Eliasaro 2794* (UPCB).

Parmotrema sanctae-candidae is known only from the type locality, an *Araucaria* forest in Paraná State, southern Brazil.

COMMENTS – *Parmotrema sanctae-candidae* is distinguished by its distinct reticulately maculate upper surface, its chemistry, and by its isidia. It is closely

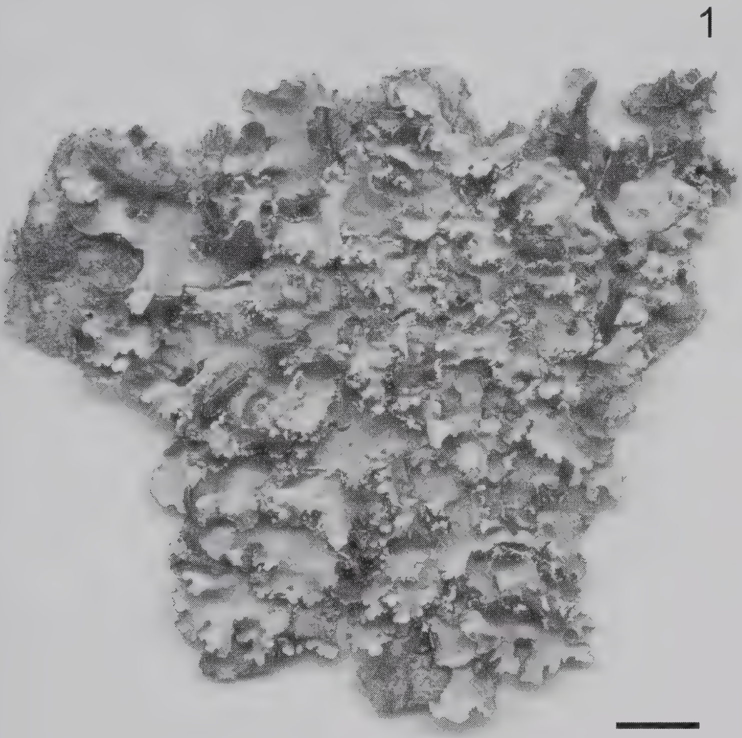

FIGURE 1. *Parmotrema sanctae-candidae* (holotype in UPCB) Bar = 9 mm.

related to *Parmotrema succinreticulatum* (Eliasaro & Adler) O. Blanco et al., which also contains succinprotocetraric acid and fumarprotocetraric acid in the medulla. The main taxonomic difference between the species is the presence of isidia in *Parmotrema sanctae-candidae.*

The only species with which *P. sanctae-candidae* might be confused is *P. subisidiosum* (Müll. Arg.) Hale, which differs in containing salazinic acid (medulla K+ yellow turning red) and in having cylindrical isidia that do not become sorediate.

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The author wishes to thank Prof. Nasser K. Hammad for checking the Latin descriptions, Dr. John A Elix and Dr. Thomas Nash III for the critical revision of the manuscript, and "Instituto ECOPLAN" for collection permits.

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MYCOTAXON

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Canoparmelia sanguinea, a new *Parmeliaceae* from Brazil

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Abstract — *Canoparmelia sanguinea*, a Brazilian species of *Parmeliaceae* from São Paulo State, is described as new to science.

Key words — *Canoparmelia caroliniana*, *Canoparmelia concrescens*, evernic acid

Introduction

Canoparmelia Elix & Hale, a segregate of the eciliate genus *Pseudoparmelia* Lynge (Hale 1976), is characterized by typically gray or rarely yellow-green thalli containing cortical atranorin and chloroatranorin [or rarely usnic acid], 3.0–5.0 mm wide, rotund or subrotund, eciliate lobes, a white medulla, a black lower surface with naked brown margins and simple concolorous rhizines, small ellipsoid ascospores 10–14 × 6–8 μm, and fusiform or bifusiform conidia 7–10 μm in length (Elix et al. 1986, Elix 1993).

The new species is based on specimens collected in the State Forest Reserve of Serra da Cantareira (23° 20'–23° 27'S, 46° 28'–46° 42'W), in an open area near the Atlantic Rainforest in the very north of São Paulo city, and adjacent municipalities.

Material and methods

The morphological characters were examined under a stereo-microscope. Anatomical sections were made with razor blades. The chemical constituents were analyzed by color reaction spot tests including potassium hydroxide (K), sodium hypochlorite (C) and paraphenylenediamine (P). All specimens were tested under UV light, and chemical constituents were identified by thin-layer chromatography (TLC) using solvent C (Bungartz 2001), high performance liquid chromatography (HPLC) (Elix et al. 2003) and comparison with authentic samples.

In the description, the Latin diagnosis refers exclusively to the holotype and the English text includes data from all the specimens examined.

Canoparmelia sanguinea Marcelli, Benatti & Elix, **sp. nov.** FIGURE 1
MB 511928

DIAGNOSIS: *Species thallo similis Canoparmelia caroliniana sed obscurior, superus rugosus vel scrobiculatus, distincte maculatus, isidiis fuscatis vel apicibus brunneis, simplicibus vel parum ramosis, arcte aggregatis, subtus niger vel atrobrunneus, medulla C+ sanguineus, KC+ sanguineus et acidis olivetolcarboxylico, 4-O-methylolivetolcarboxylico, decarboxyanziaico, decarboxystenosporico, decarboxyperlatolico, divaricatinico et glomelliferico, glomellino, et depsidellino B continens differt.*

HOLOTYPE—Brazil, São Paulo State, Municipality of Mairiporã, Cantareira Range, on a tree trunk felled during village construction, leg. M.P. Marcelli 6029, 03-XI-1989 (SP).

THALLUS sublobed, dark cinereous green becoming dusky green in the herbarium, up to 9.0 cm diam., submembranaceous, corticolous. Lobes irregularly ramified to subdichotomous, 1.0–3.5 mm wide, contiguous to imbricate in the younger parts and becoming somewhat crowded in the center, closely adnate, with subrotund or sometimes subtruncate apices, the margins entire to partly subcrenate, frequently involute, the upper surface continuous to irregularly cracked, often rugose or slightly scrobiculate especially in the older parts, ±smooth in the distal parts. MACULAE irregularly linear, laminal, becoming confluent and more conspicuous near the lobes apices, sometimes forming inconspicuous fissures. CILIA absent. LACINULAE absent, but sometimes forming small, simple, flat, subtruncate adventitious lobules in the older parts, 0.3–1.2 × 0.3–1.6 mm. SOREDIA and PUSTULES absent. ISIDIA laminal, granular to short cylindrical, 0.05–0.50 × 0.05–0.10 mm, smooth, simple to sparsely branched, generally densely clustered, not coralloid; erect, smooth, firm, partially darkened or with brown apices, eciliate. MEDULLA white. LOWER SURFACE mottled, black to dark brown, shiny to opaque, smooth to rugose, sometimes slightly veined or papillate. MARGINAL ZONE brown, shiny, 0.5–1.5 (–4.0 at the lobes apex) mm wide, less evident in some parts, smooth to rugose or veined, usually naked but sometimes sparsely papillate or rhizinate approaching the center. RHIZINAE dark brown to black, but brown or white near the marginal zone, simple to rarely furcate, acute, (0.10–) 0.20–0.70 (–1.00) × ca. 0.05 mm, frequent, ±evenly distributed. APOTHECIA not seen. PYCNIDIA rare, submarginal, with black ostioles. CONIDIA not seen.

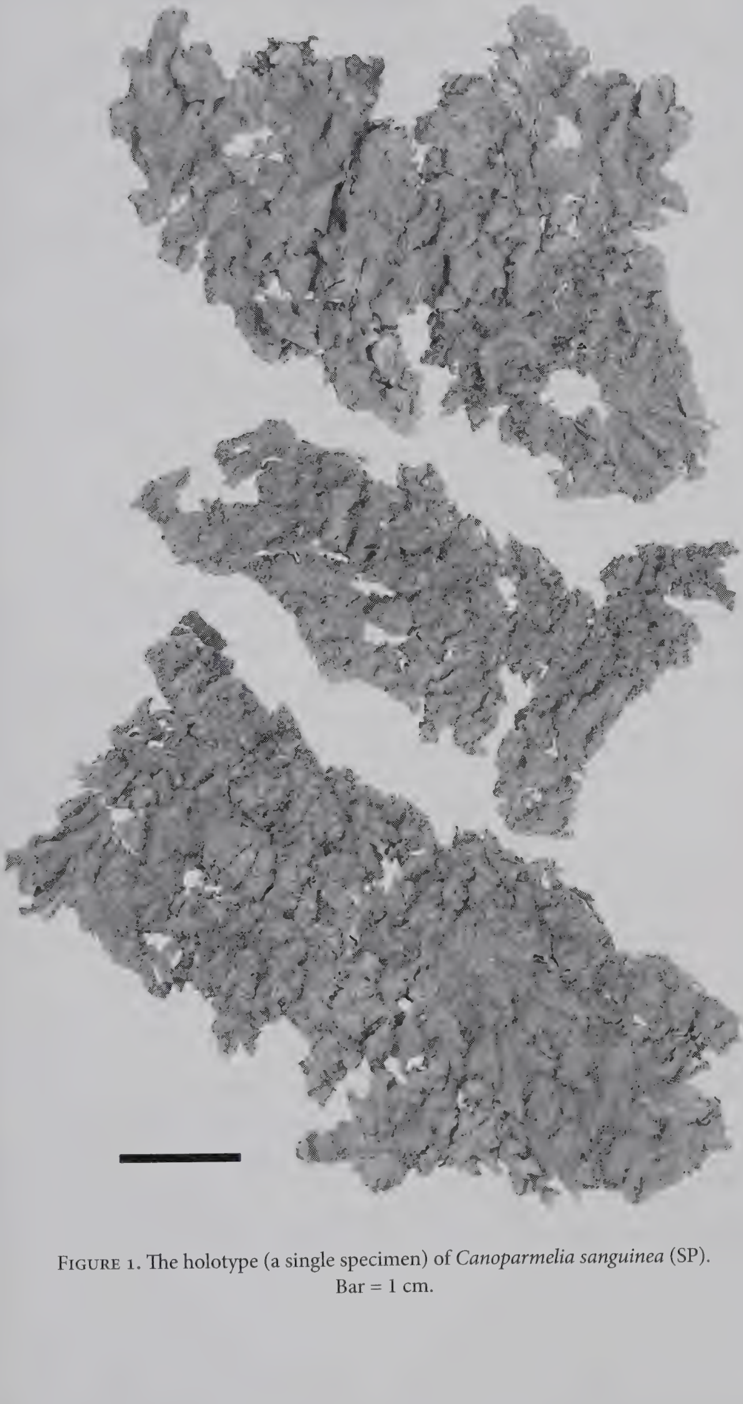

Figure 1. The holotype (a single specimen) of *Canoparmelia sanguinea* (SP).
Bar = 1 cm.

Spot tests: cortex K+ yellow, UV−; medulla K−, C+ reddish rose, KC+ red, P+ (?) very faint yellowish, UV−.

TLC/HPLC: cortical atranorin (minor); medullary olivetolcarboxylic acid (minor), 4-*O*-methylolivetolcarboxylic acid (minor), glomelliferic acid (minor/absent), glomellin (trace/minor), decarboxyanziaic acid (major), decarboxystenosporic acid (minor), decarboxyperlatolic acid (minor), divaricatinic acid (minor), depsidellin B (minor), unknowns (minor).

> Paratype–Brazil, São Paulo State, Municipality of Mairiporã, Cantareira Range, on a tree trunk brought down during village building, leg. M.P. Marcelli 6028, 03-XI-1989 (B, SP).

Comments– *Canoparmelia sanguinea* is an isidiate species which has a dark gray green thallus, imbricate or crowded lobes, often with involute margins, an almost entirely subrugose or slightly scrobiculate upper surface with prominent maculae, especially near the lobes tips, and a mottled dark brown to black lower surface. The rhizines are commonly paler in distal areas.

Due its size, overall thallus shape, the presence of isidia and prominent macules, in the field *C. sanguinea* could be mistaken for darkened specimens of the very common *C. caroliniana* (Nyl.) Elix & Hale.

However, its medullary chemistry is unique and very different from *C. caroliniana*, as was first noted by the immediate C+ and KC+ red spot tests [which in *Parmeliaceae* usually indicate the presence of the lecanoric/gyrophoric acids, olivetoric acid or anziaic acid complexes] instead of the C− and KC+ faint violet/rose reaction of *C. caroliniana* (due to the presence of perlatolic acid).

The new species produces dense, intensely clustered and ramified isidia with brown apices (which give the false impression of being coralloid), so that the isidia appear darker and more dense by comparison with those of *C. caroliniana*.

According to Hale (1976) *C. concrescens* (Vain.) Elix & Hale, another similar species, differs in having a flat, continuous, emaculate upper surface and in producing only divaricatic acid in the medulla.

This species is named after the red C and KC spot tests.

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Two new species of *Pertusaria* (*Pertusariaceae*) from China

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Abstract –– The species *Pertusaria qilianensis* and *Pertusaria paraqilianensis* from Northwestern China are described as new to science.

Keywords –– lichen, taxonomy, planaic acid

Introduction

The lichen genus *Pertusaria* in China has received little systematic study. All the taxa reported before 2004 have been revised, and the number of accepted taxa reduced to 45 (Zhao et al. 2004). A study of several recent collections of the genus from northwestern China has revealed the presence of two new species which are described here.

Material and methods

The specimens examined were collected in Qilian Mountains and Mt. Helan, Northwestern China, and are preserved in SDNU (the Lichen Section of Botanical Herbarium, Shandong Normal University).

A dissecting microscope (Motic K-400L) and a research microscope (JNOEC XS-213) were used for the morphological and anatomical studies. The lichen substances was detected by thin-layer chromatography (TLC) (Elix & Ernst-Russell 1993) and high performance liquid chromatography (HPLC) (Elix et al. 2003).

Taxonomic description

Pertusaria qilianensis Q. Ren & Z.T. Zhao, **sp. nov.** FIGURES 1–2
MycoBank MB 512348

Thallua crustaceus, cineraceus vel flavo-cineraceus, tenuis, subrimosus, superficies scaber et rugosus, isidiis et sorediis destitutis, corticola. Apothecia disciformia, numerosa

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* *Corresponding author*

> *et dispersa, 0.7–1.5 mm diam., disci nigri et sorediati, marginibus thallo concolores, laceratus et lobularis. Asci clavati, ascosporae 2nae, ellipsoideae ad ovoideae, (85–)100–180 μm longae, (40–)50–80 μm latae, parietibus laevis, 7–13 μm crassis. Thallus acidum planaicum continens.*
>
> **Typus:** CHINA. Qinghai *provincia*, Qilian, Niuxinshan, alt. 3120m, *ad corticem arborum, H. Y. Wang 20071461-1.* (holotypus in SDNU).
>
> Etymology: The specific epithet *qilianensis* is derived from the type locality in Qilian Mountains.

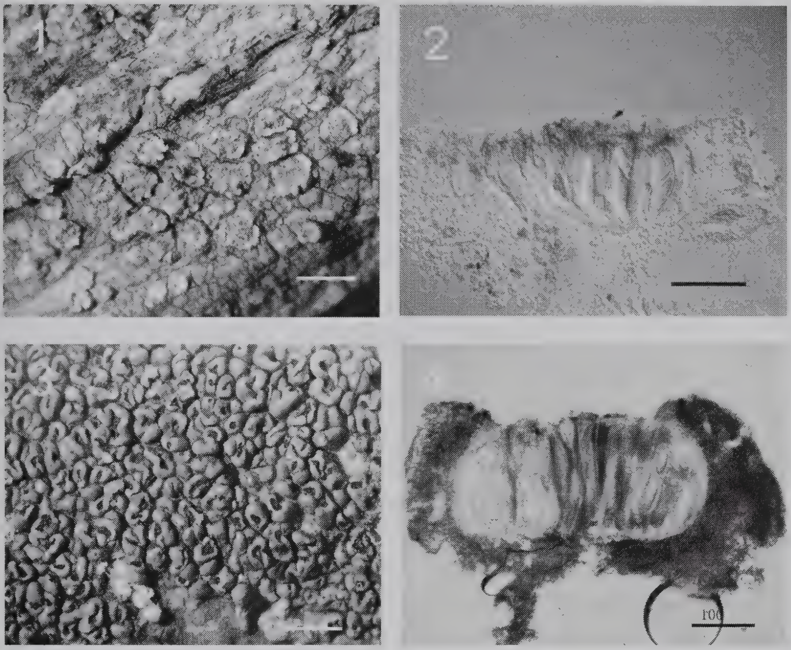
Thallus crustose, thin, very pale gray to yellowish gray, slightly cracked, surface matt and rugose; lacking isidia; corticolous; apothecia disciform, numerous, scattered, sometimes confluent, sub-immersed to sessile, constricted at the base, 0.7–1.5 mm diam., discs black, sorediate, margins lacerated and stellate, concolorous with the thallus; asci cylindric, 210–315 × 50–100 μm, 2-spored; ascospores ellipsoid to ovoid, hyaline, (85–)100–180 μm long, (40–)50–80 μm wide, double-walled, smooth, 7–13 μm thick; pycnidia not seen.

Chemistry: K–, C–, KC–, P–, UV–; planaic acid (TLC and HPLC).

Distribution and substrate —*Pertusaria qilianensis* is a corticolous species, found in northwestern China at elevations of 2670 to 3500 m.

> Specimens examined — **CHINA. Qinghai: Qilian Co.** binggou- xiaxigou, alt. 3500m, on bark 10/viii/2007, *X. L. Shi 20071426, 20071429.* niuxinshan, alt. 3050m, on bark 11/viii/2007, *H. Y. Wang & X. L. Lu 20071462, 1470-1*; *H. Y. Wang 20071461-1, 20071465-1*; *Y. D. Du 20071448-1*; alt. 3100m, on bark 11/viii/2007, *H. Y. Wang 20071485-1, 20071496*; *Y. D. Du 20071520-3*; *Z. S. Sun 20071487-1, 20071504-1*; alt. 3150m, on bark 11/viii/2007, *Z. S. Sun 20071534-2*; alt. 3200m, on bark 11/viii/2007, *Y. D. Du 20071574-2*; *J. G. Liu 20071534-2*; alt. 3250m, on bark 11/viii/2007, *Z. S. Sun 20071583-1*; *X.L. Shi 20071587-1*; alt. 3300m, on bark 11/viii/2007, *Y. D. Du 20071594*;alt. 3400m, on bark 11/viii/2007, *X. L. Shi 20071620.* **Ningxia**: Mt. Helan suyukou-beigou, alt. 2670m, on bark 22/viii/2007, *F. Yang 20072545*; (SDNU).

Comments — *Pertusaria qilianensis* is characterised by asci with two smooth ascospores, sorediate disciform apothecia and the presence of planaic acid. Planaic acid is an uncommon depside in the genus *Pertusaria* and usually present as only a trace compound. The only species in which planaic acid was reported as a major component were *P. leucothelia, P. planaica* and *P. siamensis.* The new species can be readily distinguished from the former two species by the number of ascospores. In the new species there are two ascospores per ascus in contrast to the four-spored asci in *P. leucothelia* and the eight-spored asci in *P. planaica.* The new species differs from *P. siamensis* in morphology, especially the development of apothecia, disciform apothecia compared to conspicuous verruciform apothecia in *P. siamensis* (Archer & Elix 1992, Archer 1997, Jariangprasert 2005).



Figures 1–2. *P. qilianensis*. 1. Morphology (bar = 1mm); 2. Apothecium cross section (bar = 100 µm). Figures 3–4. *P. paraqilianensis*. 1. Morphology (bar = 1mm); 2. Apothecium cross section (bar = 100 µm).

Pertusaria paraqilianensis Z.S. Sun & Z.T. Zhao, **sp. nov.** Figures 3–4

MycoBank MB 512347

Thallua crustaceus, cineraceus, crassiusculuss, surareolatus, superficies laevis et nitida, isidiis et sorediis destitutis, corticola. Apothecia disciformia, numerosa et dispersa, 0.5–1.2 mm diam., disci nigri, marginibus thallo concolores, crassus et inflated. Asci clavati, ascosporae 2nae, ellipsoideae ad ovoideae, 90–130 µm longae, 45–70 µm latae, parietibus laevis, 7–9 µm crassis. Thallus acidum planaicum continens.

Typus: CHINA. Qinghai *provincia*, Qilian, Niuxinshan, alt. 3120m, *ad corticem arborum, Z. S. Sun 20072496*. (holotypus in SDNU).

Etymology: from the Greek *para*, near, a reference to the similarity of the new species to *Pertusaria qilianensis*.

Thallus crustose, pale gray to gray, moderately thick, slightly tuberculate, surface smooth and shiny; lacking isidia and soredia, corticolous; apothecia disciform, conspicuous, numerous, scattered, sometimes confluent, sub-immersed to sessile, 0.5–1.2 mm diam., concolorous with the thallus, discs black, epruinose, margins thick and irregular inflated; asci cylindric, 200–235 × 50–85 µm, 2-spored; ascospores ellipsoid to ovoid, hyaline, 90–130 µm long, 45–70 µm wide, double-walled, smooth, 7–9 µm thick; pycnidia not seen.

Chemistry: K–, C–, KC–, P–, UV–; planaic acid (TLC and HPLC).

Distribution and substrate —At present, *Pertusaria paraqilianensis* is known from Qilian mountains, northwestern China at elevations of 3120 to 3200 m; on bark.

Specimens examined — **CHINA. Qinghai: Qilian Co.** niuxinshan, alt. 3200m, on bark 11/viii/2007, *J. G. Liu 20071572-4*; alt. 3120m, on bark 12/viii/2007, *Z. S. Sun 20072496* (SDNU).

Comments — *Pertusaria paraqilianensis* is characterised by asci with two smooth ascospores, inflated apothecia margin and the presence of planaic acid. The new species is chemically identical to *P. qinghaiensis* but that species has a conspicuous rough thallus surface, sorediate apothecia and a lacerated apothecia margin. The new species resembles the North America species *P. saximontana* but differs from that species by chemistry and the apothecia margin. *P. saximontana* has crenulate or eroded apothecium margins and contains 2-*O*-methylconfluentic acid as its major compound, whereas the new species has inflated apothecia margins and contains planaic acid (Dibben 1980, Lumbsch et al. 1999).

Acknowledgements

The authors are grateful to Professor J.A. Elix, (Australian National University, Canberra) for the liquid chromatography results. The project was financially supported by the National Natural Science Foundation (30870012) and Shandong Provincial Natural Science Foundation (Y2007D21) of China. The authors thank Dr. Alan W. Archer and Dr. André Aptroot for expert presubmission review.

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The new lichen species *Endocarpon crystallinum* from semiarid deserts in China

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Abstract — The new lichen species *Endocarpon crystallinum* was collected from semiarid deserts in China and is described in the present paper. Research on the morphology, anatomy, and chemistry of the species has been carried out. The species is unique in the genus by the thick upper cortex that is broken into columnar polygonal elements. A similar cortex structure is however known from a few, unrelated, other desert lichens and appears to be an adaptation to that climate.

Keywords — *Ascomycota*, cortex structure, *Verrucariaceae*

Introduction

During research on lichen species and their genetic diversity in the arid and semiarid deserts of northwestern China, numerous species of *Endocarpon* have been found. The genus is mainly characterized by a squamulose thallus, immersed perithecioid ascomata with hymenial algae, and asci with (1–)2(–8) muriform ascospores. Among the specimens collected was one that could not be identified with any of the known species, and it is consequently described below as new to science. The genus *Endocarpon* belongs to the *Verrucariaceae* (Kirk et al. 2001), *Verrucariales*, *Chaetothyriomycetidae*, *Eurotiomycetes*, *Ascomycota* (Geiser et al. 2006).

Materials and methods

The specimens examined were collected by either J. Yang and E.R. Zhang or T. Zhang from the deserts in the Shanxi province in northwestern China. Hand sections and squash preparations were made for anatomical study. The morphological and anatomical examinations were performed using the dissecting microscope Leica MZ8 and the biological microscope Leica DMR respectively. For chemical analysis, the standardized thin-layer chromatograph (TLC) method for identification of lichen products was used, applying solvent C (Culberson 1972, Culberson & Kristensson 1970, White &James 1985).

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Results and discussion

Endocarpon crystallinum J.C.Wei & Jun Yang, **sp. nov.** FIG. 1

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Species nova cortice supero crasso quo fracto in elementa similia crystallis, sed constantia ex textura paraplectenchymata hyalina a congeneribus diversa.

Typus: *China, Shanxi provincia: Yang-gao comitatus, Xiejiatun pagus, ad arenam, September 23, 2004, J.Yang & E.R. Zhang SX-28 (holotypus) in HMAS-L conservatur.*

ETYMOLOGY: The specific epithet "crystallinum" refers to the upper cortex of the thallus, which is covered with a broken hyaline layer reminiscent of crystals.

EXPANDED DESCRIPTION — Thallus terricolous, squamulose, consisting of small squamae, covered with a thick layer of hyaline tissue that is broken into columnar polygonal elements resembling crystals (FIG. 1 A); squamae solitary, with dark brown to black peripheral margins (FIG. 1 A), or occasionally contiguous, never imbricate, pale to yellowish brownish, rounded, elongate or irregular, shallowly to deeply lobate, 2–4(–7) mm broad.

Upper cortex consisting of two layers: the upper thick paraplectenchymatous layer of hyaline tissue that is broken into columnar polygonal elements resembling crystals in the shape of peaks is (30–)50–175 μm tall, the elements (50–)62.5–275(–475) μm wide at the base, 17.5–175(–225) μm wide at the top; the lower brownish paraplectenchymatous layer is 34–80(–110) μm tall. (FIG. 1 B)

Algal layer 38–100(–112)μm tall, consisting of subglobose and bright green cells, 5–7.5 × 5–10 μm, without visible medulla (FIG. 1 B).

Lower cortex consisting of obscure plectenchyma, dark brown to black, about 50 μm tall, with brown to black and branched rhizines of 1.5–2.5 mm long (FIG. 1 C).

Ascomata perithecioid, subglobose, uniloculate, immersed in thallus, solitary, 1–6 per squama, with brown to dark brown apex of 0.25 mm in diam. bearing a depressed ostiole lighter in color than the surrounding tissue; centrum obpyriform, 150–490 μm wide; excipulum brown to dark brown, 105–400 μm thick at the base and sides, pale brown at the apex near the ostiole; gelatinizing periphysoids 75–100 μm long, simple to sparingly branched; hymenial gel Lugol's I + blue; hymenial algal cells globose to oval, green, 2.5–5 μm in diam. or 2.5–3.5 × 3.5–5 μm (FIGS. 1D, E).

Asci fissitunicate, bisporous (FIG. 1E), clavate to cylindro–clavate, 40–60 × 15.5–21.5 μm; ascospores muriform, yellowish to brownish, elongate-ellipsoid

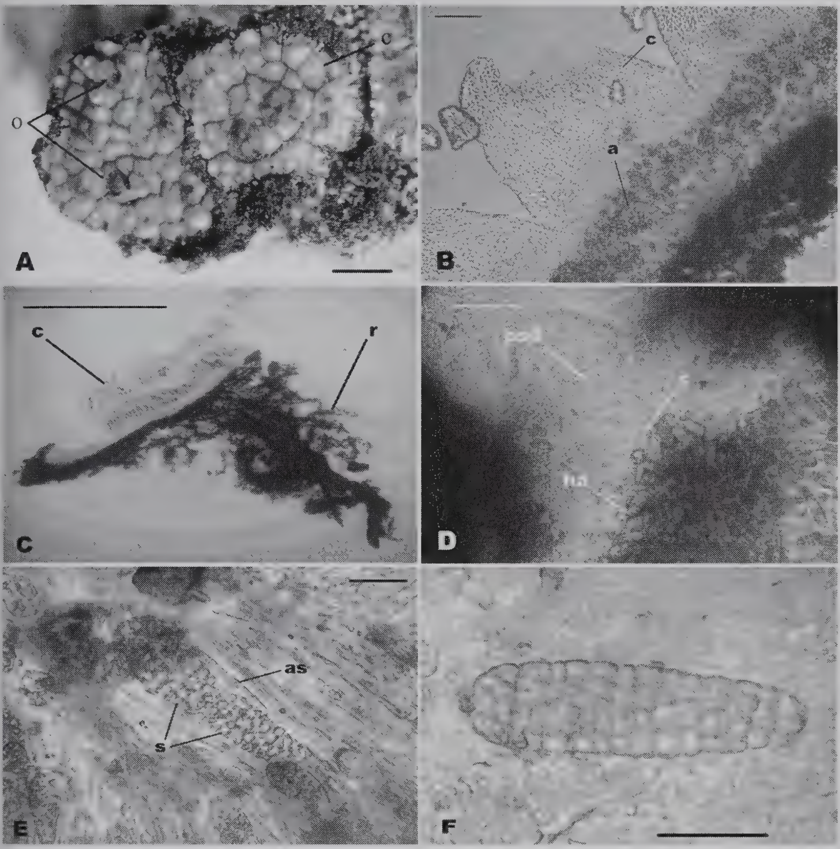

Fig. 1. A. *Endocarpon crystallinum*: Upper surface of squamae covered with minute crystal-like broken cortex elements and a few perithecioid ascomata of which only the ostioles are visible (bar = 1mm); B. Cross section of a squama (bar = 50μm); C. Cross section of a squama with branched rhizines (bar=1mm); D. The hymenial algal cells and ascospores within a perithecioid ascoma (bar = 100μm); E. An ascus containing 2 spores within a perithecioid ascoma; note that the upper spore is much broader and shorter than the lower spore (bar = 20 μm); F. A muriform ascospore (bar =20μm).

(a = algal layer; as = ascus; c = crystals; ha = hymenial algal cells; o = ostiole; psd = periphysoid; r= rhizines; s=spore; t=thallus)

to subcylindrical, with 2–4 transverse divisions and 9–15 longitudinal divisions, the upper spore much broader and shorter than the lower spore; upper spore: 50–65(–87.5) × 12.5–15μm; lower spore: (32.5–)40–50 ×15–17.5μm (Figs. 1 E,F).

Conidiomata not seen.

Chemistry: no lichen substances detected with TLC.

Additional specimens examined: **China,** Shanxi prov.: Yang-gao county: Xiejiatun, on the wall of soil, September 23, 2004, J.Yang & E.R. Zhang SX-32 (HMAS-L); west of the Yang-gao county town 2 km, on slope of soil, April 20, 2007, J. Yang & T. Zhang, SX-093, SX-113 (HMAS-L); Ningxia Autonomous region, Xiang mountain of Shapotou region, soil among rocks; April 17, 2007, J. Yang & T. Zhang SPT-202 (HMAS-L).

Comments: This new species resembles in its upper cortex structure several other unrelated lichens from desert habitats. Examples are *Psora crystallifera* and several *Toninia* species (Timdal 1991), e.g. *T. albilabra* and *T. sculpturata*. The congruence is so striking that Fig. 2E in Timdal (1991), taken from *Toninia albilabra*, is indistinguishable from Fig. 1B below, taken from the new species, which belongs to a different order (and even class). This structure is undoubtedly an adaptation to desert climate.

The new species differs from other members currently accepted in the genus (Breuss 2002, Harada 1993, McCarthy 1991) by the thick upper cortex that is broken into columnar polygonal elements resembling crystals, but made of hyaline paraplectenchymatous tissue.

Acknowledgments

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Gloeocantharellus persicinus, a new species from China

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Abstract — *Gloeocantharellus persicinus* is described as a new species from China supported by macro- and microscopic photographs. It is compared with *G. echinosporus, G. lateritius, G. okapaensis, G. purpurascens* and *G. uitotanus*. The holotype (GDGM 21480) is deposited in the Herbarium of Microbiology Institute of Guangdong Province (GDGM).

Key words — taxonomy, *Gomphaceae*, cantharelloid fungus

Introduction

Gloeocantharellus Singer is a small genus of *Gomphaceae* with only 6 species recognized (Singer 1945, Corner 1969, Petersen 1971, Vasco-Palcacios & Franco-Molano 2005). The genus is characterized by its numerous gloeoplerous hyphae, gloeocystidia, ornamented spores, and bifurcate lamellate to slightly wrinkled hymenophore (Singer 1945, Corner 1969, Ainsworth et al. 1973). All species of *Gloeocantharellus* are terrestrial and generally found associated with ectomycorrhizal trees. Five species of *Gloeocantharellus* have been reported from Asia, i.e. *G. corneri* (Singer) Corner, *G. echinosporus* Corner, *G. lateritius* (Petch) Corner, *G. okapaensis* (Corner) Corner, and *G. purpurascens* (Hesler) Singer (Lloyd 1917, Corner 1969, Pegler 1986, Yuan & Sun 1994, 2007). However, the only *Gloeocantharellus* recorded for China — *G. purpurascens* — should be excluded, because the field photographs (Yuan & Sun 1994, 2007) and re-examination of the specimens (HKAS 15708) showed that the basidiomata represented *Gomphus clavatus* (Pers.) Gray, not *Gloeocantharellus purpurascens*; furthermore, the cited specimens, with basidiospores 13–16 × 6–7.5 µm, do not have any gloeocystidia.

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During a survey on the mycoflora of E'huangzhang Nature Reserve in Yangchun County of Guangdong Province, a species belonging to *Gloeocantharellus* was discovered and it possesses some distinguishing features from any known species. A new species is therefore proposed as follows.

Materials and methods

Specimens were annotated and photographed in the field, dried in an electric drier, and then deposited in herbarium. Tissues were mounted in 5% KOH for microscopic examination. The lengths and widths of 20 spores were randomly selected, and Q represents the mean length/width of the 20 spores. The microscopic characters were observed under light microscope and scanning electronic microscope. Colour references are presented according to Kornerup & Wanscher (1978). The holotype has been deposited in the Herbarium of Guangdong Institute of Microbiology (GDGM).

Taxonomy

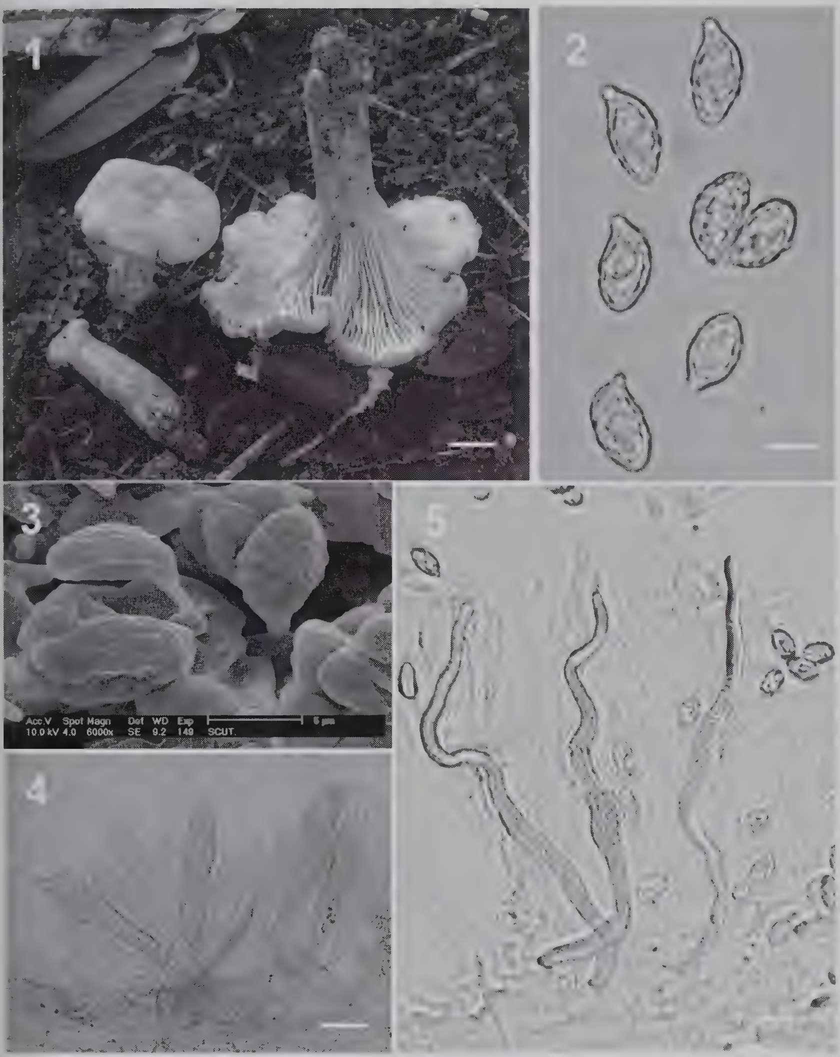
Gloeocantharellus persicinus T.H. Li, Chun Y. Deng & L.M. Wu, **sp. nov.**

MycoBank MB 511995 Figs. 1–5

Basidiomata 4–6 cm alta, gomphoidea vel cantharelloidea cum hymenophora lamellata. Pileus 3.8–7.0 cm × 3.5–6.0 cm, convexus dein applanatus vel infundibuliformis, viscidulus, dilute aurantiacus, rufulo-aurantiacus vel persicinus; margine undulatus vel valvatus, primo incurviusculus. Contextus albus, tactu immutabilis. Lamellae albidae, flavidae vel cerinoflavidae cum coloratione olivaceo-grisea, subconfertae, 9–12 per cm, < 3.5 mm latae, decurentes, inaequales, saepe furcatae. Stipes 4–4.5 cm × 0.9–1.1 cm, cylindraceus, basim versus attenuatus, centralis vel eccentricus, concolor cum pileo vel pallidulus quam pileus. Basidiosporae (7.8–)8.6–10.1 × 4.1–5.8 μm, ellipsoideae, verruculosae, ochraceae, inamyloideae. Basidia 36–50(–70) × 6–10 μm, clavata, 2–4-sterigmata 5–8 μm longis. Gloeocystidia lanceolata vel subclavata, hymenialia, 42–80(–160) × 4.5–9 μm. Pileipellis et stipitipellis ixocutis, cum hyphis oleiferis. Hyphae oleiferae 2.9–7.3 μm latae. Hyphae 2.9–5μm latae, fibulatae.

Type collection — CHINA, Guangdong, Yangchun County, 15 May 2004, T.H. Li & L.M. Wu [GDGM 21480, holotype].

Basidiomata 4–6 cm tall, gomphoid to cantharelloid in general contour but with obvious lamellate hymenophore. Pileus 3.8–7.0 cm × 3.5–6.0 cm, convex then plane to infundibuliform, usually depressed at centre, subviscid, light orange or reddish orange to peach-colour (6A4, 7A4, 7A6, 8A4); margin wavy or valvate, initially inflexed. Context white, bruising unchanged. Lamellae whitish to pale yellow (4A1 to 4A3) tinted with olive-grey (4D2) , becoming olive-grey, olive-brown to light brown (4D2, 4D4 to 5D4) when dried, crowded, 9–12 per cm at pileus-margin, <3.5 mm wide, deeply decurrent, unequal, sometimes bifurcate but not or hardly anastomosing, edges even. Stipe 4–4.5 cm long, 0.9–1.1 cm thick at apex, cylindrical, equal to slightly enlarged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Figs. 1-5: *Gloeocantharellus persicinus* (holotype). 1. Basidiomata; 2-3. Basidiospores 4. Basidia in hymenium; 5.Gloeocystidia in hymenium.
Bars: 1 = 1 cm; 2 = 5µm; 3 = 5 µm; 4 = 10 µm. 5 = 10 µm.

downwards, tapered at base, central to slightly eccentric, mostly concolorous with the pileus, peach-colour, pastel red to pale red (7A4,7A3), in some parts paler or whitish.

Basidiospores (7.8–)8.6–10.1 × 4.1–5.8 µm (x=9.7 × 5.2, n= 20, Q=1.86), elongate ellipsoid, ornamented with strongly cyanophilic warts, yellow to cinnamon brown in mass, pale yellow to pale cinnamon in KOH under microscope, inamyloid. Basidia 36–50(–70) × 6–10 µm, clavate, hyaline, with 2–4 sterigmata 5–8 µm long. Pileipellis an ixocutis of a compact layer of repent and interwoven gelatinous hyphae with gloeoplerous hyphae. Pileus context of thin-walled, parallel to closely interwoven hyphae; gloeoplerous hyphae frequent, tortuous, rarely branched, some terminating among basidia. Stipe context of packed hyphae of two types: (1) thin-walled, parallel, hyaline, 2.9–5 µm in diam., and (2) gloeoplerous, tortuous, aseptate, interwoven, yellow, 2.9–7.3 µm in diam., common and abundant. Gloeocystidia 42–80(–160) × 4.5–9 µm, completely immersed to slightly projecting beyond the hymenium, thin-walled, lanceolate to subclavate, with yellow contents in H_2O and KOH. Stipitipellis formed of parallel and narrow hyphae, with some gloeoplerous hyphae. Caulocystidia not observed. Clamp connections abundant.

Habitat, distribution and season — Single to scattered, on soil in broad-leaved forest; China (Guangdong). May.

Comments—*G. persicinus* is similar in colour to three other pinkish to orange red Asian species, i.e. *G. echinosporus*, *G. lateritius,* and *G. okapaensis*. However, the basidiospores of *G. echinosporus* are obviously spiny and wider; in *G. lateritius* the basidiospores are larger (10–13.5 × 6–7 µm) and the context turns purplish on exposure; and in *G. okapaensis* the pileus is dry, the context becomes dingy vinaceous mauve on bruising, and the basidiospores are also larger (9–12 × 5–7 µm) (Corner 1969, Pegler 1986). Macroscopically, the new species resembles *G. purpurascens*, but that North American species has larger basidiomata and distinctive purple or violet discoloration on the bruised parts of the basidiome (Smith & Hesler 1943). Another red species, *G. uitotanus* Vasco-Pal & Franco-Mol. originally described from Central America, can also be distinguished, the pileus being deeper red to reddish brown (8C8-9C8), the basidiospores larger [(8–)8.8–12 × (4–)4.8–6(–6.4) µm], and the lamellae narrower (up to 2 mm broad), fewer (subdistant), subdecurrent rather than decurrent, and more strongly anastomosing than those of the new species (Vasco-Palacios & Franco-Molano 2005).

Acknowledgements

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Critical review of recent records of *Russulaceae* from Panama

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Abstract — Based on recently collected specimens, four new records of the *Russulaceae* are presented for Panama: *Russula* aff. *densissima, R. luteotacta, R. mexicana* and *Lactarius* aff. *lilacinus. R.* aff. *densissima* is reported for the first time for the Americas. The Panamanian specimens of *R. luteotacta, R. mexicana* and *L.* aff. *lilacinus* are the most southern records for the Americas. All species are described and illustrated. A discussion of their known distribution, delimitation from morphologically similar species, and their taxonomy is added, where applicable.

Key words — tropical mycology, Central America

Introduction

Tropical fungi are largely under-explored and the analysis of their diversity, abundance, and taxonomy is far from complete. Especially taxonomically challenging groups, like the *Russulaceae*, are badly known, because species recognition and species demarcation demands a high degree of familiarity with the group and the methods of identification. Only few monographs for taxa outside Europe and North America are available (Buyck 1990, 1994, 1998, Chiu 1945, Heim 1937, 1938a, b, 1955a, b, 1970, Hongo 1960, Karhula et al. 1998, Kong Luz 1995, McNabb 1973, Nuytinck et al. 2006a, b, Singer et al. 1983, Verbeken 1996, 1998, 2001, Verbeken & Horak 2000, Verbeken et al. 2000). These reasons make this group harder to approach than many other groups of Basidiomycota.

Piepenbring (2006) assembled a checklist of fungi for Panama. With view to the *Russulaceae,* she only listed four records of *Russula* spp. published by Buyck & Ovrebo (2002). In order to identify recently collected specimens from Panama, European and American monographs of *Russula* (Bon 1988, Einhellinger 1985, Romagnesi 1967, 1985, Sarnari 1998, 2005) and *Lactarius* (Basso 1999, Heilmann-Claussen et al. 1998, Hesler & Smith 1979) as well as fungus-floristic studies of other countries (Dennis 1970, Halling & Mueller 2005, Kimbrough 2000, Kreisel 1971, Mata 1999, Mata et al. 2003, Franco-Molano et al. 2000, Pegler 1983, Singer 1975, Singer et al. 1983, Stevenson 1975) including *Russulaceae* were used. In addition, a checklist of tropical *Russula* spp. was consulted (Buyck 1992, 1993). The synonymy of the recorded species is listed as far as the authors can agree to it.

Materials & methods

The present study is based on collections made by M. Piepenbring and coworkers during their field work and mycological courses held at the Universidad Autónoma de Chiriquí, in Panama. These specimens are deposited at the National Herbarium of Panama (PMA) and the Botanische Staatssammlung in Munich (M). They were analyzed macroscopically and microscopically with a Carl Zeiss Stemi 2000 and a Jenalab microscope. Microphotographs were taken with a Sony 3 CCD-hig camara. SEM images were made at the Institute for Systematic Zoology and Evolution at the FSU Jena. The identifications were critically reviewed by R.-M. Rauschert (Freyburg, Germany), G. Weber (Schwarmstedt, Germany) and A. Gminder (Jenaprießnitz, Germany). The Panamanian specimens were compared with specimens from personal herbaria.

The known distribution of the identified species is presented based on data from literature and specimen records deposited in the National Fungus Collection of the U.S. Department of Agriculture (BPI), at the University of Michigan Herbarium (MICH), the New York Botanical Garden (NY), and the Oregon State University (OSC). These collections, however, were not analyzed in the context of the present study.

Results & discussion

Lactarius

Lactarius **aff.** ***lilacinus*** (Lasch: Fr.) Fr., PLATE 1; 3: FIG. 1–5; FIG. 13
Epicr. syst. mycol. (Upsaliae): 348 (1838).

SYSTEMATIC POSITION (Heilmann-Claussen 1998): Subgenus *Piperites,* section *Colorati*

SPECIMEN VISUM: **Panama: Chiriquí.** Parque Nacional Volcán Barú, Sendero los Quetzales, under *Alnus acuminata* Kunth, alt. approx. 2500 m, 20.X.2007, M. Piepenbring with licenciatura students 4078 (PMA & M-0140998).

Macroscopic features: BASIDIOMATA (FIG. 1–2) grouped on soil under *Alnus acuminata;* PILEUS 1.2–1.4 cm diam., brick to orange brown, surface dry to somewhat viscid when wet, smooth, at first convex to applanate with a decurved margin, later depressed, often remaining decurved, often with a small umbo; STIPE 2.5–3 cm × 0.3–0.5 cm, cortex ochraceous to orange brown, with a whitish rain-soaked tomentum-like not completely covering layer, beneath it glabrous, overall cylindrical, often irregularly furrowed or rugged, base rounded and dented; CONTEXT fragile, becoming hollow in the stem, cream to pale pinkish buff, in outer parts concolorous with the cortex, taste mild, slowly becoming spicy to slightly bitter, smell not documented; latex rather sparse, white; LAMELLAE pale pinkish buff, later apricot-ochraceous, broadly adnate to decurrent, sometimes slightly intervenose, sometimes forked, crowded to rather distant; SPORE PRINT not observed.

Microscopic features: SPORES (FIG. 13) 5.9–8.7 × 5.1–6.9(–7.7) µm, broadly ellipsoidal to ellipsoidal, ornamentation more or less completely reticulate, 0.75–1 µm high, of warts and short ridges in between, plage inamyloid; CYSTIDIA pleuromacrocystidia numerous, cylindrical, with an obtuse or somewhat mucronate apex, cheilomacrocystidia (FIG. 5) rather numerous, cylindric to slightly clavate, with an obtuse apex; PILEIPELLIS (FIG. 3-4) with poorly developed cutis, oedotrichoderm with trichoderm-like parts, dermatocystidia absent.

Hesler & Smith (1979) state the possibility of *L. lilacinus* occurring in North America but they had never seen a specimen from North America when they published their monograph. The herbarium (MICH), however, contains several specimens of *L. lilacinus* collected in the eastern and the southeastern USA from 1936 to 1939 (C.H. Kauffman. 19 Aug 1919, H.C. Beardslee Jr. 36069, H.C. Beardslee Jr. 36137, H.C. Beardslee Jr. 39057). Most identifications made by mycologists in the first half of last century — particularly those not familiar with the origins of the fungal names they used — should be treated with great skepticism. Thus, those USA records for *L. lilacinus* must be regarded as doubtful. *Lactarius lilacinus* is well known from Europe (Heilmann-Claussen et al. 1998, Basso 1999). To date, this species apparently has not yet been cited for Central or South America. *L. lilacinus* is recorded here for the first time for Central America.

L. lilacinus grows on damp soil in association with *Alnus* spp. *Lactarius* species associated with *Alnus* may occur down to Colombia where *Alnus* has its most Southern distribution in America.

In the past, the European *L. lilacinus* has been confused with *L. spinosulus* Quél. because of the pinkish colors they both have. *L. spinosulus* is distinguished by a stronger zonate and scalier cap. The species are easily separated by different microscopic characteristics (Heilmann-Claussen et al. 1998). *L. spinosulus* has not yet been documented for North America, neither in literature (Hesler & Smith 1979) nor by the consulted herbaria. The pileus is somewhat orange in the Panamanian specimen, which might cause confusion with other orange species in the subgenus *Russularia*. Alder-associated species would include *L. lacunarum* and the species around *L. obscuratus* – and possibly other species listed by Hesler & Smith (1979), Heilmann-Claussen et al. (1998) and Basso (1999).

The Panamanian specimen, however, shows some deviating features compared with literature data for *L. lilacinus.* Macroscopically the smaller basidioma size is conspicuous when compared with the size as indicated in literature, i.e. 1.5–8.0(–14.0) cm for the pileus and 1.5–5.5(–7.0) × 0.3–2.0(–2.5) cm for the stipe (Heilmann-Claussen et al. 1998, Basso 1999). This might be explained by the tropical origin of the Panamanian specimen. The availability of mineral nutrients like soil-bound nitrogen, potassium, and phosphate often limits the productivity of humid tropical forests (Lodge, 1993). Most nutrients are concentrated in plant biomass and poor anion and cation exchange capacity in the soils results in constant leaching out of the soils due to the high rainfall (Jordan 1985, Lodge 1993). This is one possible explanation for smaller basidioma sizes noted for tropical *Russulaceae* and other ectomycorrhizal macrofungi strongly dependent on nutrition from their host trees.

Another deviation between the Panamanian specimen and typical *L. lilacinus* collections is the absence of pinkish tinges in the pileipellis and the smoother, hardly velutinous pileus surface (Heilmann-Claussen et al. 1998, Basso 1999). Additionally, most basidiomata carry a small umbo upon their pileus. The seemingly slightly shorter spores (Fig. 13) and the oedotrichoderm of the Panamanian specimen contrast with literature descriptions for *L. lilacinus.* All in all, these deviating characteristics create a habitus that is strongly reminiscent of *L. lacunarum* Romagn. ex Hora but which is contradicted primarily by spore measurements and the obtuse cheilomacrocystidia (Fig. 5). Latex colour changes can be rather inconsistent, i.e. in the *L. fulvissimus* complex, a close relative of *L. lacunarum*. Therefore we consider the observed differences in the latex colour changeability as of minor importance. A bigger range of macromorphological variation appears to be likely in tropical habitats because of the continuous rainfalls and possibly because of the extremely heterogeneous conditions of nutrient availability in the soil in tropical habitats. This makes microscopic data more reliable. Thus, we identify the Panamanian specimen as *L.* aff. *lilacinus.* More data from further specimens will show whether it corresponds to a new forma or a new variety of this species.

Russula

Russula* aff. *densissima Jul. Schäff. ex Romagn., Plate 1; 3: Fig. 6; Fig. 14–15
Bull. trimest. Soc. mycol. Fr. 96(3): 297 (1980).
Syn. *Russula densifolia* f. *densissima* Jul. Schäff. nom. inval.
? *Russula fuliginosa* Sarnari

Systematic position (Sarnari 1998): Subgenus *Compactae,* section *Compactae,* series *Acrifolia*

Specimen visum: **Panama: Chiriquí.** Parque Nacional Volcán Barú, Sendero los Quetzales, alt. approx. 2500m, on soil under *Quercus* sp., 20.X.2007, M.Piepenbring with licenciatura students 4085 (PMA & M-0140999).

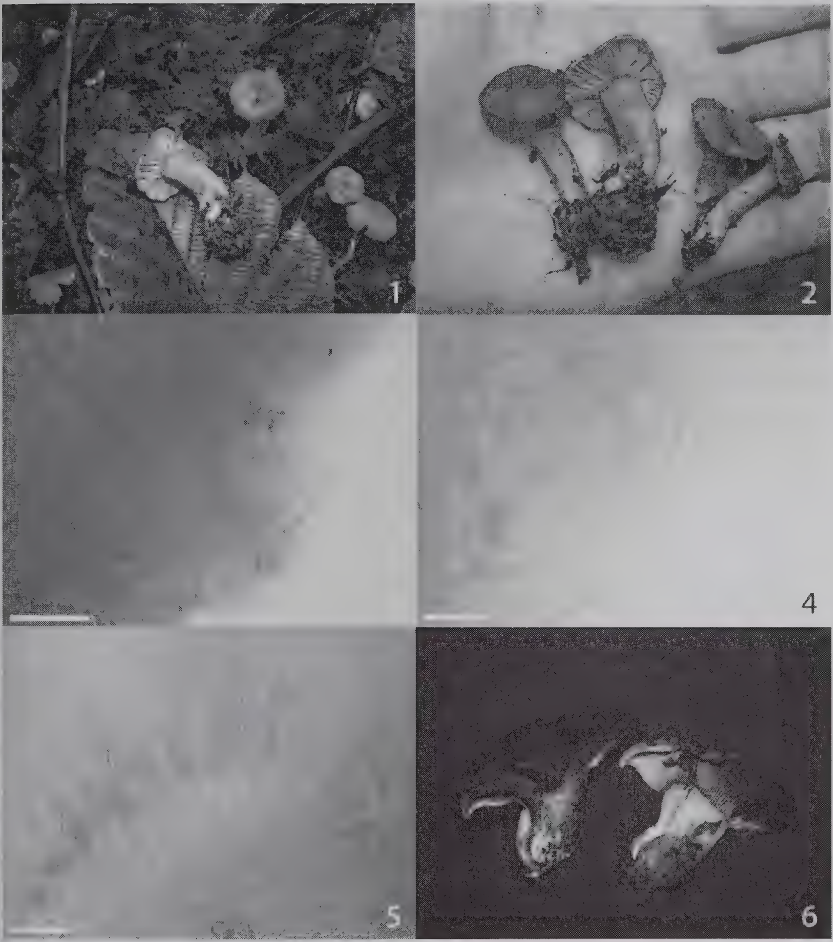

PLATE 1: **1-5 *Lactarius* aff. *lilacinus*** (Piepenbring 4078). 1–2 Fresh specimen; 3 Longitudinal section of pileipellis, scale 50 µm; 4 Longitudinal section of pileipellis, terminal elements, scale 20 µm; 5 Longitudinal section of lamellar edge, cheilomacrocystidia, scale 20 µm; **6 *Russula* aff. *densissima*** (Piepenbring 4085). 6 Fresh specimen.

Macroscopic features: BASIDIOMATA (FIG. 6) solitary on soil under *Quercus* sp.; PILEUS 3 cm diam., brownish to pale grayish especially at the margin or with yellowish to whitish specks, viscid and shiny when fresh, rapidly and strongly blackening after injury or when old, depressed, later cyathiform, margin rounded, later straightened; STIPE short, 2 × 1.3 cm, cortex white, then sordid black or soot black blotchy, pruinose, slightly enlarged at the top, overall nearly cylindrical, base rounded and dented; CONTEXT white, with soot black blotches in the stipe, at first becoming fuliginous, then blackening without reddening, firm and rigid, odor not distinct, taste acrid in the lamellae, mild in the stipe; LAMELLAE whitish, becoming fuliginous and black in age or after injury, decurrent or inserted obliquely, very rarely forked, very crowded (24–28 lamellae per cm); SPORE PRINT not obtained.

Microscopic features: SPORES (FIG. 14) (6.2–)6.5–7.2(–9.2) × 5.6–6.5(–7.2) µm, subglobose, covered by an interrupted reticulum formed by low, hemispherical warts 0.25–0.5 µm high, partly interconnected; PILEIPELLIS epicutis with cylindrical to clavate to subulate dermatocystidia (FIG. 15) with hyaline or granular-refringent content in the segments.

Russula densissima has been described from France recently by Romagnesi (1985). This species has only rarely been found by the authors of the European *Russula* monographs. Romagnesi (1985) reported it from acidic soil under different deciduous trees accompanied by some conifers, while Sarnari (1998) collected it exclusively under *Quercus* sp. on clayey moderately calciferous soil. The Panamanian specimen has also been found in association with *Quercus* sp. Thus, it is likely that this species is neither strictly acidophilous nor dependant on calciferous soil and it probably prefers *Quercus* spp. as mycorrhizal partner.

This is the first record of *R.* aff. *densissima* for the Americas, as there are no records in literature or in the consulted herbaria. Central American records of closely related species, such as *Russula densifolia* (Secr.) Gill., have been reported by Gómez & Alfaro (1996) from Costa Rica. Other members of the section *Compactae* ss. Sarnari resp. *Nigricantae* ss. Romagnesi (e.g. *R. nigricans* (Bull.) Fr.) have also been found in North America. Corresponding specimens have been deposited in the herbaria BPI, MICH, NY, and OSC.

R. densissima is difficult to distinguish from *R. densifolia.* In contrast to *R. densissima, R. densifolia* has a reddening context, darker lamellae, and less globose spores (Romagnesi, 1985). Discussing the variety of forms of *R. densifolia,* Schaeffer (1952) already recognized hardly reddening rare collections around Potsdam (Germany) with extremely crowded (16 lamellae per 8 mm margin), slender, acutely marginate gills and only slightly acrid taste with a strong smell of *R. adusta* Fr., which he preliminarily called *R. densifolia* f. *densissima.* Another earlier monographic study of the section *Compactae* of *Russula* (Shaffer 1962) primarily based on North American material also analysed the critical group around *R. densifolia.* Discussing this issue, Shaffer (1962) implies that the great variability of several features in all the different forms of *R. densifolia* and adjacent species makes it difficult to base taxa only on such differences. As an example several personal collections of *R. densifolia* with mild taste and only slowly reddening basidiomata are mentioned that approach *R. adusta.* The extremely crowded lamellae in *R. densifolia* f. *densissima* compared with the variation of this feature in *R. densifolia*, for example, was not considered significant by Shaffer (1962).

Sarnari (1998) suggests *R. densissima* as taxon affinum of *R. fuliginosa* but most other specialists of *Russula* do not accept *R. fuliginosa* as a separate species (G. Weber, pers. com.). *R. densissima* differs from *R. fuliginosa* in a smaller sized pileus, subulate terminal segments of pileus hyphae (cylindrical in *R. fuliginosa*), and the ~1–1.5 µm shorter spores. The fruiting body of the specimen from Panama is smaller than in literature (Romagnesi 1985, Sarnari 1998), which should not be considered as unusual in view of its tropical montane origin (comp. above). The spore measurements of the Panamanian specimen are intermediate between *R. densissima* [6.5–7.2(–7.7) × 5.7–6.5(–7) µm, cf. Romagnesi 1985] and *R. fuliginosa* [7.2–8.8 × 5.6–7 µm, cf. Sarnari 1998].

Russula luteotacta Rea, PLATE 2; 3: FIG. 7–9; FIG. 16–17
Brit. basidiomyc. (Cambridge): 469 (1922).

SYSTEMATIC POSITION (Sarnari 1998): Subgenus *Russula,* section *Russula,* subsection *Sardoninae,* series *Persicina*

SPECIMEN VISUM: **Panama: Chiriquí.** Alto Chiquero, Finca de Maria Amoruso, alt. approx. 1750 m, on soil under *Quercus* sp., 11.IX.2007, M. Piepenbring, J. Vega & A. del Cid 3982 (PMA & M-0141000).

Macroscopic features: BASIDIOMATA (FIG. 7–9) grouped on soil under *Quercus* sp.; PILEUS 4.5 cm diam., light red to pink, strongly discoloring by rain, dry, shape first convex, later leveled and depressed in the center, margin rounded and incurved; pileipellis strongly adhering, difficult to separate from the pileus trama; STIPE 5.7 × 1.1 cm, club-shaped, cortex white, glabrous, base rounded, at the beginning rigid, later spongy and fragile; CONTEXT white, not yellowing when injured, spongy, odor not known, taste acrid; LAMELLAE (FIG. 9) white, more or less decurrent, intervenose at the base, not forked, distant, not yellowing when injured, fragile; SPORE PRINT white (Ia–b).

Microscopic features: SPORES (FIG. 16) (6.5–)7–8.5 (–9) × (5.5–)6–7 µm, mostly ellipsoidal, rarely subglobose, ornamentation verrucose to subspinose, formed by mostly isolated elements, about 0.7 µm high, connections rare and short; PILEIPELLIS epicutis formed by dense, slender hyphae and cylindrical, flexuous, very long and voluminous dermatocystidia (FIG. 17), dermatocystidia obtuse or attenuated in an obtuse bottleneck, nearly constricted-capitate, often septate, content of oily appearance, reacting greyish to sulfovanilline.

According to Singer et al. (1983), this species can also be found in the neotropical lowlands. In Europe it is mostly associated with *Carpinus* spp., but can also be found in association with other species of *Fagales* on clayey, sometimes soggy soil (Romagnesi 1967, 1985, Singer et al. 1983). The Panamanian specimen is the first record of *Russula luteotacta* for Panama and for Central and South America, as no further American record than BPI 764448 from Maryland (USA) could be found in literature or in herbaria.

Taxonomists generally agree on the concept established for *R. luteotacta.* Lamellae mostly become chrome yellow when injured, but unchanging collections are not rare (Sarnari 1998). The latter is also the case in the Panamanian specimen – this is the only atypical feature of the collection. Other features such as the distant lamellae, the color of the spore print, the fragility of the fruiting body and the color of the pileipellis are typical.

Russula mexicana Burl., PLATE 2; 3: FIG. 10–12; FIG. 18–19
Mycologia 3: 26 (1911).

SYSTEMATIC POSITION (Sarnari 1998): Subgenus *Russula,* section *Russula,* subsection *Sardoninae,* series *Sanguinea*

SPECIMEN VISUM: **Panama: Chiriquí.** Las Nubes, Alto Chiquero, close to the house of ANAM, alt. approx. 1770 m, on soil under *Quercus* sp., 26.VIII.2007, M. Piepenbring, with licenciatura students 3945 (PMA & M-0141001).

Macroscopic features: BASIDIOMATA (FIG. 10–11) grouped on soil under *Quercus* sp.; PILEUS 4–6.5 cm diam., light red at the margin, center pallescent, dry, shape first convex, than umbilicate, later more broadly depressed in the center; STIPE 4–6.3 × 0.8–1.7 cm, cylindrical, cortex pinkish, glabrous, base round; CONTEXT whitish, rigid, eventually becoming fragile in age, odor not recognizable, taste acrid; LAMELLAE whitish, straightly to recessed adnate, hardly intervenose, a few forked, close to moderately close; SPORE PRINT not obtained.

Microscopic features: SPORES (FIG. 12, 19) 6.5–8 × 6–6.5 µm, subglobose-ellipsoidal, covered by blunt cylindrical to acute conical spines, mostly isolated elements, 0.8–1.7 µm high, scarcely interconnected by a few fine ridges; PILEIPELLIS epicutis consisting of hyphal ends which in the central part of the pileus mostly tend to be clavate, and of some dermatocystidia (FIG. 18) with mostly rounded, subcapitate or slightly constricted terminal segments, mostly with hyaline and sometimes granular content (terminal segment mostly hyaline), reaction to sulfovanilline negative on desiccated material, staining of acid resistant elements by carbolic fuchsine on the dry specimen showed a granular incrustation by those elements at some of the dermatocystidia at the subterminal and sometimes also at the terminal segments of the dermatocystidia (FIG. 18).

The locality of the type (NY 653949) is situated in Mexico, near Jalapa. According to Singer et al. (1983) this species seems to be common in mixed forests from the Great Lakes region (e.g. Michigan, Illinois) south to subtropical and perhaps tropical belt of North and Central America.

Singer et al. (1983) presumes that this species occurs in lowland pine and oak forests south of Mexico, at least in plantations. The specimen Piepenbring 3945 is the first record of *Russula mexicana* for Panama and the most southern

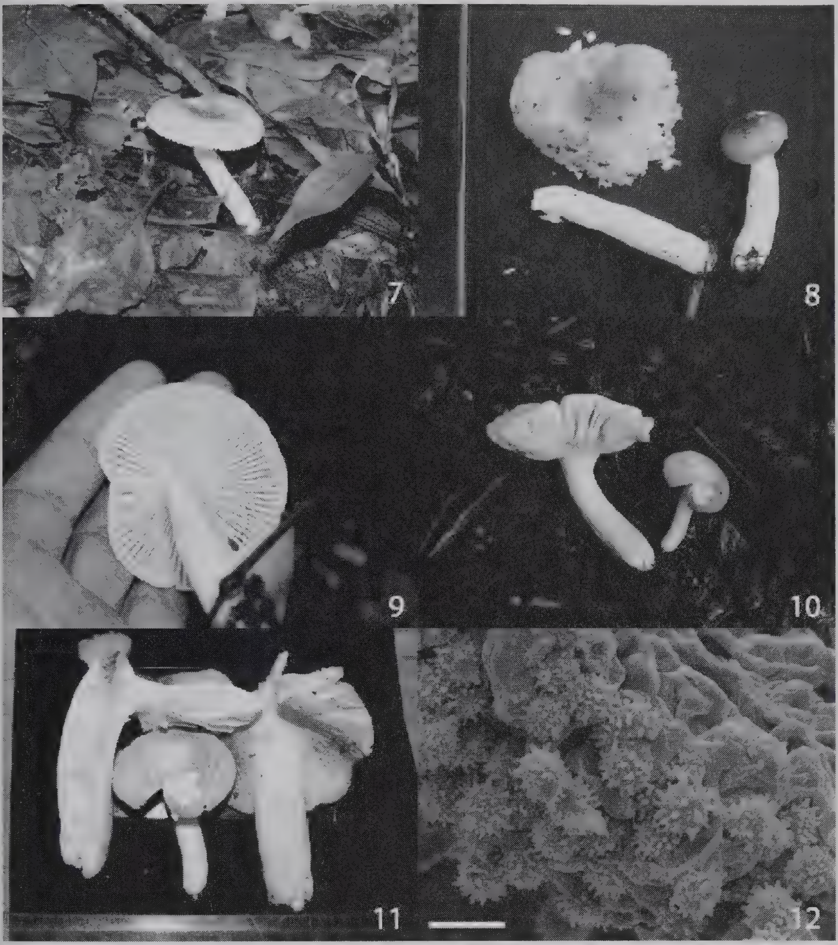

Plate 2: **7-9 *Russula luteotacta*** (Piepenbring 3982). 7–9 Fresh specimen; **10–12 *Russula mexicana*** (Piepenbring 3945). 10–11 Fresh specimen; 12 SEM image of spores, scale 10 µm.

report for this species in the Americas. Additional Central American records are published by L. Lacey for Belize (http://web.cortland.edu/baronit/Belize/list.asp) and Gómez & Alfaro (1996) for Costa Rica.

Several authors consider *R. mexicana* conspecific with *R. sanguinea* (Bull.) Fr., as no significant differences could be found in the type specimens (Bills & Miller 1984, Sarnari 1998), while other authors record them as separate species (Singer et al. 1983, Gomez et al. 1996, G. Weber, pers. com.). Additionally, Kong Luz (http://www.*Russula*mx.com) states that the type specimen of *R. mexicana* is immature and therefore of limited use. The specimen from

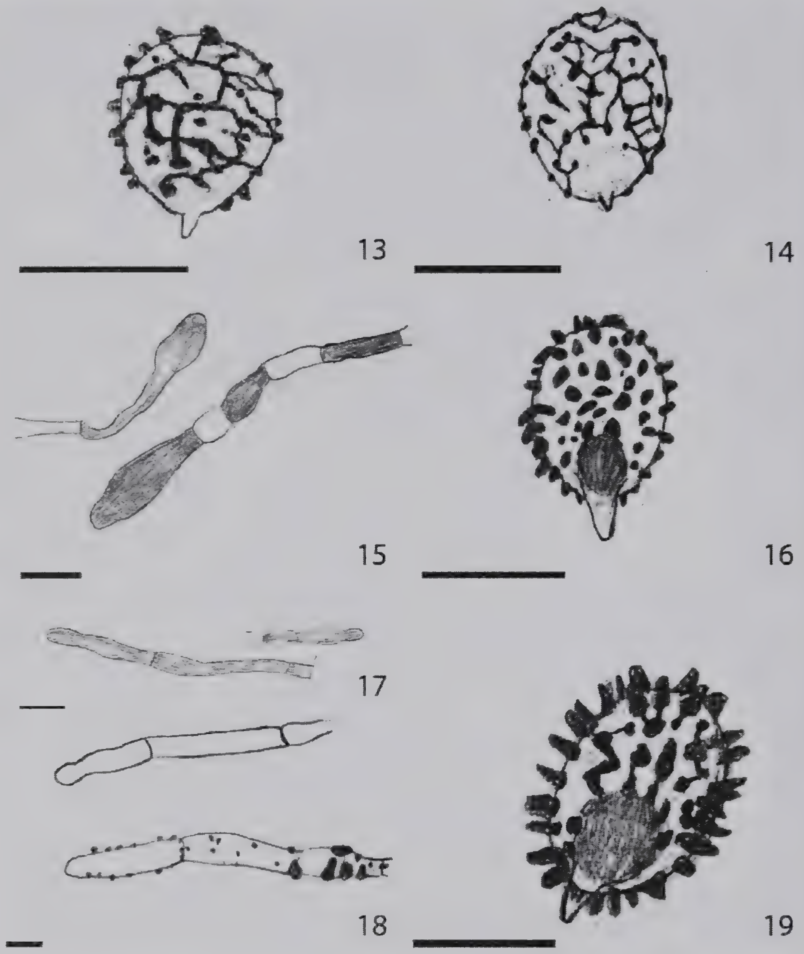

Plate 3: **13** ***Lactarius*** **aff.** ***lilacinus*** (Piepenbring 4078). 13 Spore, scale 6,5 µm; **14-15** ***Russula*** **aff.** ***densissima*** (Piepenbring 4085). 14 Spore, scale 7 µm; 15 Dermatocystidia, scale 20 µm; **16–17** ***Russula luteotacta*** (Piepenbring 3982). 16 Spore, scale 6 µm; 17 Dermatocystidia, scale 10 µm; **18–19** ***Russula mexicana*** (Piepenbring 3945). 18 Dermatocystidia, scale 10 µm; 19 Spore, scale 6 µm.

Panama corresponds to *R. mexicana* rather than *R. sanguinea*, chiefly because of the shared habitat and apparent association with oaks. In contrast, *R. sanguinea* grows exclusively under *Pinus*, *Russula mexicana* prefers montane *Quercus* forests. Another striking difference is the spore ornamentation in the Panamanian specimen, which consists of spines that are much longer and rougher than in *R. sanguinea,* where the spines only reach up to 1 µm in height.

Apart from the spore ornamentation, the habitat is currently considered as the only reliable feature for the separation of the two species.

Macroscopically *R. mexicana* differs by its glabrous stipe apex and its thinner pileus cuticle (Singer et al. 1983). *R. mexicana* is supposed to have a deep cream colored spore print of IId (Singer et al. 1983) while the spore print of *R. sanguinea* is described as pale ochraceous (IIIa) (Bon 1988, Romagnesi 1985) or approximately IId (Sarnari 1998).

In general, the default assumption should be that the synonymy between American and European taxa cannot be taken for granted, even in the absence of clear morphological differences. The problem of a lack of significant differences between the type of *R. mexicana* and *R. sanguinea* is certainly to be taken seriously. Thus, it would be good to provide a modern, detailed description of *R. mexicana* making this point. Such a study is in progress.

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Three new species of *Cortinarius* subgenus *Phlegmacium*

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Abstract — Based on morphological and molecular phylogenetic studies we present three new species in *Cortinarius*. Species descriptions are provided, along with discussions of phylogenetic and morphological affinities to similar taxa. *Cortinarius majoranae, Cortinarius aquilanus* and *Cortinarius lepistoides* spp. nov. are described. The first taxon is placed in section *Percomes*, whereas the last two belong to section *Caerulescentes*.

Keywords — taxonomy, phylogenetic relationships, European distribution

Introduction

Species delimitation of *Cortinarius* species is difficult, and the number of accepted species and the application of names vary greatly in the modern literature. Several recent studies of *Cortinarius* have employed phylogenetic analyses of nuclear ribosomal gene sequence data from ITS (the internal transcribed spacer region) and nLSU (nuclear large sub unit) in combination with morphological studies with success (Ammirati et al. 2007, Frøslev et al. 2005, 2006, 2007, Garnica et al. 2003a, b, 2005, Høiland & Holst-Jensen 2000, Kytövuori et al. 2005, Lindström et al. 2008, Liu et al. 1997, Moser & Peintner 2002, Niskanen et al. 2006a, b, Peintner et al. 2001, 2003, 2004, Seidl 2000).

In this paper we present three new species of *Cortinarius* based on morphological studies and phylogenetic analyses of the ITS region, *Cortinarius aquilanus, C. lepistoides* and *C. majoranae.*

Material and methods

The taxonomic descriptions are primarily based on the material studied by the authors. The measurements of macro morphological characters are based on expanded, but never old (and then often aberrant) basidiocarps. Macro chemical reagents applied were 2% and 40% KOH. The terminology of characters follows Brandrud et al. (1990) with minor adjustments (see Brandrud 1996).

Microscopical structures were observed partly from fresh material mounted in H_2O, often with a drop of 40% KOH subsequently added, and partly from dried material mounted in H_2O and then KOH. The descriptions of the pigment topography are based largely on observations from H_2O mounts of fresh, preferentially young material. The spores were studied and measured in 2 % KOH, with a 100× oil immersion lens. From each basidiocarp, a random selection of mature spores obtained from cortina remnants were measured excluding apiculus and ornamentation. Young, immature basidiocarps were avoided. For species with many available specimens ten spores were measured per specimen. For species with few available collections thirty or more spores were measured per specimen. Mean values (MV) of spore length and width as well as Q–values (length/width ratio) were then calculated for each specimen. MVs were calculated for each taxon. The pileipellis was studied from radial (longitudinal), free hand sections, preferentially from fresh material. Wedge-like sections, ultra thin at the one end, were obtained by cutting at a slightly oblique angle. The sections were cut from approx. 5 × 5 × 3 mm large pieces taken from young but expanded pilei, and at a position midway to the centre.

ITS sequence data obtained for this study were amplified and sequenced according to the methods in Frøslev et al. (2005). Holotypes and representative material of most relevant similar species were studied morphologically and molecularly. Results of the molecular phylogenetic studies will not be presented here. Collections marked with "†" have been sequenced.

Herbarium acronyms follow Holmgren et al. (1990). The following acronyms are used in collection numbers: TF=Tobias Guldberg Frøslev and TSJ=Thomas Stjernegaard Jeppesen. Colour photographs of most species and many of the collections cited here are available on www.cortinarius.com (Frøslev & Jeppesen 1999–2008).

Taxonomic descriptions

Cortinarius aquilanus T.S. Jeppesen & Frøslev, **sp. nov.**

MycoBank MB 512354

Pileo 35–80 mm lato, hemisphaerico, dein plano-convexo, glutinoso, fibrilloso, ochraceo-brunneo vel luteo-brunneo, ad marginem pallido ochraceo, KOH ope indistincto. Velo universale sparso. Lamellis emarginatis, griseis. Stipite 35–65 × 8–20 mm, albido, dein interdum luteo maculato, bulboso, bulbo distincte marginato, vel 35 mm lato. Carne albida, in apice stipitis pallida grisea, sapore subnullo, KOH ope luteo in stipe, aurantio-brunneo in bulbo, Sporis amygdaliformibus, ellipsoideis, distincte verrucosis, 9–10.5 × 5.5–6.5 µm. Typus: DENMARK: Horsens, Elbæk skov, 21 Oct 2006, T.S.J., TSJ2006-110 (holotype C).*

Etymology: Latin - after eagle (*Aquila*), in reference to the locality, Ørnereden ("The eagle nest") in Århus, Denmark.

Pileus 3.5–8 cm, (hemi-)spherical, then plano-convex, glutinous, glabrous and glossy, innately fibrillose, brown, ochre brown to yellow brown, margin pale buff, slightly hygrophanous in very moist weather. Universal veil remnants fairly sparse, and very thin with a "frosty" appearance (cf. *Cortinarius glaucopus*). LAMELLAE crowded, emarginated, greyish white, becoming ± ochre. STIPE 3.5–6.5 × 0.8–2.0 cm, with a sharply marginated bulb (–3.5 cm), whitish, with age often staining somewhat yellowish in streaks or spots. CONTEXT whitish, when young with ± greyish tinge at stipe apex, becoming ± yellow in damages. SMELL ± malty. TASTE mild. MACROCHEMICAL REACTIONS: 2% and 40% KOH on pileus negative to slightly brownish, in stipe context yellow to orange-yellow, in bulb orange brown.

SPORES 9–10.5 × (5–)5.5–6.5 µm (MV= 9.58 × 5.74 µm, Q=1.67, n=61, 2 specimens), amygdaloid to ellipsoid, distinctly verrucose. PILEIPELLIS duplex: cutis fairly thin, consisting of 10–15 layers of 2–4 µm wide hyphae with zebra-striped pigment incrustations. HYPODERM fairly weakly developed, of up to 12 µm wide, sausage-shaped elements, embedded in yellow-brown parietal pigment.

ECOLOGY AND DISTRIBUTION – *Cortinarius aquilanus* occurs in nemoral *Fagus sylvatica* forests on calcareous or mineral rich soils.

SPECIMENS STUDIED – (*including macro characters): DENMARK: Fyn: Odense, Fruens bøge, 3 Oct 2000, T.S.J., *TSJ2000-044**† (herb C), Jutland: Århusskovene, 3 Oct 2004, T.S.J., *TSJ2004-059**† (herb C), *loc. cit.*, 30 Aug 2005, T.S.J, *TSJ2005-002**† (herb C), Horsens, Elbæk skov, 21 Oct 2006, T.S.J., *TSJ2006-110**† (holotype; herb C); Møn, Klinteskov, 12 Sept 2006, T.F., *TF2006-070**† (herb. C). – SWEDEN: Skåne: Degeberga, Herremöllan, 30. Sept 2003, T.S.J., *TSJ2003-082** (herb. C)

COMMENTS – *Cortinarius aquilanus* is a fairly anonymous *Phlegmacium* species with pale stipe and lamellae and ochraceous brown to yellow brown pileus, and a yellow to orange-yellow reaction in the context with KOH. *Cortinarius xanthoochraceus* P.D. Orton is superficially very similar, but has a more distinctly yellow, less fibrillose pileus, a negative reaction with KOH, and smaller spores. *Cortinarius multiformium* Consiglio & Moënne-Locc., *C. gracilior* (M.M. Moser) M.M. Moser, and *C. luteoimmarginatus* Rob. Henry differ by having citriform (papillate) spores. *Cortinarius saporatus* Britzelm. is larger, has distinct velum remnants on a less fibrillose pileus, and larger, more coarsely ornamented spores. *Cortinarius langeorum* Frøslev & T.S. Jeppesen is larger, has larger, more coarsely ornamented spores, and a reddish alkaline reaction on the pileus. *Cortinarius talus* Fr. has a less distinct bulb, a honey-like smell, and smaller spores. *Cortinarius multiformis* Fr. grows with conifers and has a more or less honey-like smell.

The protologue of *C. aurantiotinctus* Bidaud in many ways corresponds well with the present species and mentions a distinct KOH reaction. However, the holotype of *C. aurantiotinctus* yielded an ITS sequence identical to *C. xanthoochraceus* and should most likely be treated as a synonym hereof. We do not know whether the protologue of *C. aurantiotinctus* is based on a mixed concept or aberrant specimens of either species, but the holotype material definitely does not belong with the present species.

Phylogenetically *C. xanthoochraceus* seems to be the closest relative of *C. aquilanus*. The phylogenetic separation is unambiguous with more than 20 nucleotide differences and several indels. *Cortinarius xanthoochraceus* was included in the study of Garnica et al. (2005) under the name *C. langei* (TUB 011861) and was placed close to the lineages Caerulescentes and Phlegmacioides. A similar placement of both species is also indicated by our analyses.

The ITS sequence data were identical for all examined material. An ITS sequence of the Danish holotype of *C. aquilanus* (TSJ2006-110) is deposited at GenBank under the accession number FJ195642.

Cortinarius majoranae Frøslev & T.S. Jeppesen, **sp. nov.**

MycoBank MB 512355

> *Pileo 35–100 mm lato, hemisphaerico, dein plano-convexo, interdum umbonate, glutinoso, primo luteo, dein ad centro olivaceo vel olivaceo-brunneo, minuto granulato, KOH ope virido vel olivaceo. Velo universale indistincto. Lamellis emarginatis, viridi-luteis vel luteis. Stipite 50–80 × 15–25 mm, clavato vel clavato-bulboso, bulbo interdum indistincto marginate, virido-luteo vel luteo, ad basis e velo aurantio-luteo vel brueeno, mycelium virido-luteo. Carne virida-lutea, sapore subnullo, KOH ope in stipite et pileo indistincto olivaceo, in bulbo indistincto roseo. Odore distincto, ad C. percomis. Sporis ellipsoideis vel amygdaliformibus, grosse verrucosis, 11–12.5 × 7–8 µm. Typus: SWEDEN: Öland, Åstad, 21 Sept 2003, T.S.J., TSJ2003-034* (holotype C).*
>
> Etymology: Latin - after the marjoram-like smell

Pileus 5–10 cm, hemispherical to convex, then expanded, often with low umbo, glutinous, glabrous and glossy, at first bright lemon yellow, soon becoming olivaceous to olivaceous brown from centre, often ±granulate-diffracted at centre. Lamellae crowded, emarginate, greenish yellow to sulfur yellow. Stipe 5–8 × 1.5–2.5 cm, clavate to ± abruptly bulbous, greenish yellow to sulfur yellow, in lower half with pale orange yellow to brownish veil remnants. Mycelial strands greenish yellow. Context greenish yellow. Smell distinct, like marjoram or apple-cake, similar to the smell of *C. percomis*, Taste mild but with components of the smell. Macrochemical reactions: KOH on pileus greenish to olivaceous, in bulb context indistinctly reddish, in pileus and stipe context indistinctly olivaceous.

Spores 11–12.5 × (6.5–)7–8 µm (MV=11.51 × 7.4 µm, Q=1.55, n=45, two specimens), ellipsoid to slightly amygdaloid, coarsely verrucose. Pileipellis simplex: Cutis thick, consisting of 30–35 hyphal layers. At surface 10–15 gelatinous layers of 2.5–3.5 µm wide, loosely erect-entangled, hyaline hyphae. The basal part of 20–30 layers of parallel to ±interwoven, 4–6 µm wide hyphae. Hyphae with intracellular granulate pigment, becoming wine red in 2% KOH.

Ecology and distribution – *Cortinarius majoranae* occurs in temperate deciduous forests. It has been found associated with *Tilia* and *Quercus* on calcareous soils, and seems to be extremely rare, but widespread. So far it has been recorded in Sweden, the Czech Republic, and France.

Specimens studied – (*including macro characters): CZECH REPUBLIC: Prague, Karlstejn, 21 Sept 2002, T.F. & T.S.J., TSJ2002-018*† (herb C). – SWEDEN: Öland, Åstad, 21 Sept 2003, T.S.J., TSJ2003-034*† (holotype; herb. C). – FRANCE: Jura, Arbois, 3 Oct 1998, T.F. & T.S.J., TF1998-116 (herb. C), TSJ1998-135 (herb. C), loc. cit., 14 Oct 2000, T.S.J. & T.F., TF2000-098 (herb. C), TSJ2000-087 (herb. C), loc. cit., 1 Oct 2006, T.S.J. & T.F., TSJ2006-083 (herb. C).

Comments – *Cortinarius majoranae* is easily recognized by the peculiar (greenish) yellow basidiocarps and context, the clavate to slightly abruptly bulbous stipe, and a smell similar to that of *C. percomis*. *Cortinarius majoranae* has a greenish to olivaceous pileus and grows with frondose trees, whereas *C. percomis* has an orange yellow pileus and grows exclusively with *Picea*. *Cortinarius aurilicis* Chevassut & Trescol and *C. xanthosuavis* Bon & Trescol occur in the same habitats as *C. majoranae* and can be very similar, but both have a faint smell of banana peel, not of marjoram or apple-cake. *Cortinarius aurilicis* furthermore has an umbra brown oxidation of the pileus and saffron-orange mycelial strands. We have seen the species both with a clavate stipe typical for species around *C. percomis* but also with an abruptly bulbous stipe. The bulb is the considerably less developed than in species belonging to the sections *Caerulescentes*/*Glaucopodes* and *Calochroi*/*Fulvi*, but comparable to that of *C. aurilicis*.

The taxonomic status as a separate species was confirmed by a unique phylogenetic position when comparing sequence data from *C. majoranae* with representative specimens of most other putative taxa in the section *Percomes*.

Phylogenetically *C. majoranae* is placed in section *Percomes* along with similar species such as *C. nanceiensis* Maire, *C. aurilicis*, *C. percomis* Fr. and *C. mussivus* (Fr.) Melot, with which it shares the granulate diffracted pileipellis, extractable, yellow, anthraquinonoid pigments, peculiar smells, and a cylindrical to sub-bulbous stipe. It is phylogenetically distinct from all other tested material from the section. It is placed as a sister to a lineage composed of *C. nanceiensis* and *C. aurilicis* with more than 50 nucleotide differences to any of these.

We did not succeed in amplifying ITS sequence data from the French specimens. The Swedish and the Czech material were identical in the ITS region. The ITS sequence data were identical for all examined material. An ITS sequence of the Swedish holotype (TSJ2003-034) of *C. majoranae* is deposited at GenBank under the accession number FJ195641. The holotype sequence has partial ITS1 and ITS2 regions, and a more the more complete sequence of the Czech collection (TSJ2002-018) is deposited under the accession number FJ195640.

Cortinarius lepistoides T.S. Jeppesen & Frøslev, **sp. nov.**
MycoBank MB 512356

> *Pileo 30–70 mm lato, hemisphaerico, dein plano-convexo, glutinoso, primo violaceo-caeruleo vel violaceo-griseo, dein griseo, ad centro brunneo-griseo, KOH ope luteo-brunneo. Velo universale indistincto, brunneo. Lamellis emarginatis, griseis, ad marginem distincto violaceo. Stipite 40–60 × 8–15 mm, caeruleo, dein pallido-caeruleo, bulboso, bulbo distincte marginate, vel 25 mm lato. Margine bulbi e velo lilaceo-violaceo. Carne albida, in apice stipitis caerulea, interdumin bulbo lutea, sapore subnullo, KOH ope luteo-brunneo. Odore sub-nullo, Sporis limoniiformibus, distincte verrucosis, 8.5–10 × 5–6 µm. Typus: DENMARK: Jylland: Vosnæs Havskov, 30 Sept 2000, TF & TSJ, TF2000-056 (holotype C).*
>
> Etymology: Latin, after *Lepista*, due to the superficial resemblance to *Lepista nuda*.

Pileus 3–7 cm, hemispherical to convex, then expanded, glutinous, glabrous and glossy, violaceous blue to dark violaceous grey, with radiate hygrophanous streaks when young, soon becoming greyish with darker grey brown centre, and ± hygrophanous appearance, often with very thin and indistinct frosty veil, becoming yellow brown under adhering grass, leaves etc. Lamellae greyish with distinctly violaceous edge. Stipe 4–6 × 0.8–1.5 cm, with a marginate bulb (–2.5 cm), blue at first, discolouring whitish from below, with violaceous blue veil at bulb margin. Context whitish, in stipe bluish at first, soon becoming whitish, becoming slightly yellowish in bulb. Smell indistinct. Taste mild. Macrochemical reactions: KOH on pileus yellow brown and in pileus context, somewhat weaker in stipe and bulb.

Spores 8.5–10 × 5–6 µm (MV=9.38 × 5.48 µm) Q=1.71 (n=90, two specimens), limoniform, distinctly and densely verrucose. Pileipellis duplex: Cutis fairly thin, consisting of 10–15 layers of 2–4 µm wide hyphae with intracellular granulate pigment. Hypoderm well developed, consisting of up to 30 µm wide, subcellular elements, embedded in yellow-brown parietal pigment.

Ecology and distribution – *Cortinarius lepistoides* occurs in temperate deciduous forests on calcareous soils. It is associated with *Fagus sylvatica, Quercus* and possibly *Corylus,* and seems to be extremely rare but widespread throughout Europe. It is known with certainty from Denmark, Sweden, Germany and Hungary.

> Specimens studied – (*including macro characters): DENMARK: Jutland, Vosnæs havskov, 17 Oct 1999, T.F. & T.S.J., *TSJ1999-094**† (herb C), *loc. cit.*, 30 Sept 2000, T.F. & T.S.J., *TF2000-056**† (holotype; herb. C). – FRANCE: Dordogne, Notre-Dame-de-Sanilhac, 4 Oct 2002, G. Eyssartier, *GE02.074*† (herb. PC). – HUNGARY: Visegrádi Mts, Tahi, 11 Nov 2003, Bálint Dima, *DB628*† (herb. Dima). – SWEDEN: Öland, Odens, 3 Oct 1998, Pirjo & Ilkka Kytövuori, *IK 98-2650*† (herb. H).

Comments – *Cortinarius lepistoides* is recognized by the initially blue pileus becoming brownish and rust spotted, conspicuous violaceous lamellae edge, and citriform spores. It is closely related to the similar species *C. viridocoeruleus*

Chevassut & Rob. Henry and *C. camptoros* Brandrud & Melot, but differs from these by its initially violaceous blue pileus. Furthermore *C. camptoros* lacks the distinctly violaceous lamellae edge seen in *Cortinarius lepistoides* and *C. viridocoeruleus*. *Cortinarius viridocoeruleus* has larger spores than *C. lepistoides* and *C. camptoros*.

Cortinarius imperialis Bidaud and *C. subhygrophanus* Bidaud show similarities towards *C. lepistoides*, but the holotypes of both these species have amygdaloid spores. Sequence data of *C. subhygrophanus* place this species very close to *Cortinarius arcifolius* Rob. Henry, and also close to *C. moënne-loccozii* Bidaud, but not as a relative of *C. lepistoides*. The holotype material of *C. imperialis* and *C. subhygrophanus* originate from the same location, and the descriptions and illustrations in Bidaud et al. (1993) indicate that they most likely represent the same species, and therefore should be treated as synonyms.

Cortinarius lepistoides is little known, but has been included in some publications. It was treated by Eyssartier (2004) under the name *C. imperialis* (GE 02074) accompanied by a nice photograph and a discussion including references to our initial publication of the species under the misapplied name *C. camptoros* on www.cortinarius.com (Frøslev & Jeppesen 1999–2008). An examination of Eyssartier's material revealed that it belongs to *C. lepistoides*. The ITS data was identical to all other sequenced material and the spores were limoniform and not amygdaloid as stated in the description in the text (Eyssartier 2004). An exact sequence match indicates that *Cortinarius lepistoides* was also included in the study of Garnica et al. (2005) under the name *C. viridocoeruleus* (TUB 011408, GenBank no# AY174788).

Phylogenetically it is most closely related to *C. camptoros* and *C. viridocoeruleus* and placed in the phylogenetic lineage called *Caerulescentes* in Garnica et al. (2005) containing species traditionally treated in sections *Glaucopodes* and *Caerulescentes*. The species has three polymorphic sites in the ITS region of which two show intragenomic polymorphisms as well, and the polymorphisms do not divide the examined specimens into separate groups.

An ITS sequence of the Danish holotype (TF2000-056) of *C. lepistoides* is deposited at GenBank under the accession number FJ195643. An ITS sequence from a collection from the exact same locality (most likely the same mycelium) the year before (TSJ1999-094) is deposited under the accession number FJ195644. The two sequences are identical.

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The first report of *Neoramularia bidentis* from Europe

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Abstract — *Neoramularia bidentis*, hitherto known only from a few Korean localities, has recently been found in southern Poland. The habit, morphology and ecology of this species and its host, *Bidens tripartita*, are described, discussed and compared with *Neoramularia spissa*, and *Ramularia concomitans*, a similar hyphomycete on *Bidens* species.

Key words — anamorphic fungi, hyphomycetes, distribution

Introduction

The genus *Neoramularia* U. Braun was introduced by Braun (1991). After the modification of the circumscription and subsequent redispositions (Braun 1998, Shin & Braun 1996), it now comprises ten species worldwide. They parasitize mostly dicots, and only *Neoramularia phragmitis* (Nagorny) U. Braun has been found on a member of the family *Poaceae*, viz. *Phragmites australis* (Cav.) Trin ex Steud. (compare Table 1). While four *Neoramularia* species are known exclusively from their type localities, *Neoramularia kochiae* (Woron.) U. Braun, *N. oxytropidis* (Jacz.) U. Braun, *N. phragmitis*, *N. rubi* (Bubák) U. Braun and *N. spissa* (Harkn.) U. Braun occur more abundantly (Braun 1998). *N. bidentis* should now be added to this more widespread group.

The description of *Neoramularia bidentis* is based on material collected by Shin in South Korea in 1992 (Shin & Braun 1993). Although it was repeatedly observed in Kangung and Seoul in the following years (Shin & Kim 2001), this species was not found outside South Korea (Farr et al. 2008). However, *Neoramularia bidentis* has recently been collected in Poland during studies on micromycetes in southwest part of the country. It is the first confirmed locality of this species both in Poland and in Europe.

Material and methods

Native to the Polish vascular plant flora (Mirek et al. 2002), *Bidens tripartita* L. is widespread in the whole country (Zając & Zając 2001). This plant is a permanent element of communities belonging to the Bidentetea class which develop on drying shores of inland water bodies (Matuszkiewicz 2006). In these habitats, *Bidens tripartita* coexists and competes with anthropophytes: *B. frondosa* L., and, on a lesser scale, with *B. connata* Muhl. ex Willd. (Kucharski 1992), considered to be an alien invasive species (NOBANIS, www.nobanis.org).

Infected host plants were collected in a poor meadow (Junco-Molinietum association) with the participation of species of the Bidentetea class. The fungus occurred abundantly on wild-growing *Bidens tripartita* from June to September 2006.

The collected host plants were air-dried and examined by standard light microscopy (LM). Measurements of conidia and conidiophores, mounted in lactophenol cotton blue and warmed, were taken. The monograph by Braun (1998) was used for determination. The examined collections are deposited at LOD and LBL.

Table 1. Host range and worldwide distribution of *Neoramularia* species*

Neoramularia species	host (family)	distribution
N. bidentis	*Bidens* (*Asteraceae*)	South Korea, Poland
N. capparis	*Capparis* (*Capparaceae*)	India
N. esfandiarii	*Scrophularia* (*Scrophulariaceae*)	Iran
N. karelii	*Vitex* (*Verbenaceae*)	Turkey
N. kochiae	*Ceratocarpus*, *Eurotia*, *Kochia* (*Chenopodiaceae*)	Central Asia, Caucasus, Europe
N. koreana	*Stachys* (*Lamiaceae*)	South Korea
N. oxytropidis	*Oxytropis* (*Fabaceae*)	Europe, North America
N. phragmitis	*Phragmites* (*Poaceae*)	Central Asia, Caucasus, Europe
N. rubi	*Rubus* (*Rosaceae*)	Central Asia, Caucasus, Europe
N. spissa	*Euthamia* (*Asteraceae*)	North America

*source: Braun (1998), Shin & Braun (1996).

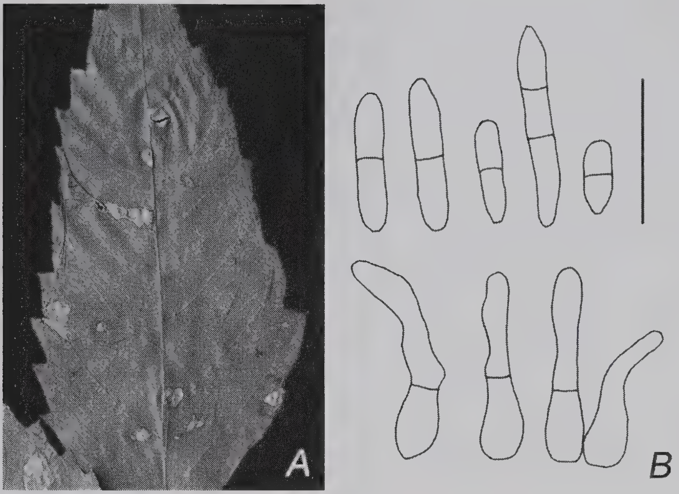

Fig. 1. *Neoramularia bidentis*: **A**, Leaf spots on *Bidens tripartita*; **B**, Conidiophores and conidia; scale bar = 20µm; A. Wołczańska *del.*

Description and discussion

Neoramularia bidentis H.D. Shin & U. Braun, Mycotaxon 49: 352. 1993.

Leaf spots irregular, 2–15 × 2–5 mm, the largest one usually elongated, yellowish brown with very thin, dark brownish margin (Fig. 1). Caespituli hypophyllous. Conidiophores solitary or in small loose groups, erect, cylindrical with slightly bulbose base, narrowed towards the tip, apex rounded, 18–32 × 4 µm, up to 7 µm wide at the base (Braun 1998: 20–32(–55) × 4(–7) µm). Conidiogenous loci inconspicuous. Conidia 0–2-septate (mostly 1-septate), cylindrical or fusoid, hyaline, 14–30 × 3.5–4.5(–5) µm (Braun 1998: 10–34 × (2.5–)3.5–5 µm). Hila neither thickened nor darkened.

Specimens examined – **POLAND. Śląskie voivodeship:** Wola near Pszczyna, Junco-Molinietum association, on *Bidens tripartita* – 22.VI.2006; Ruszkiewicz-Michalska & Myszka (LOD PF *2886*); the same host, locality and collectors, 24.VII.2006, 28.VIII.2006, 10.IX.2006 (LOD PF *2913, 2934, 3081,* LBL M *8652*).

The Polish specimens agree well with the original description of *N. bidentis* except for somewhat shorter conidiophores. Another *Neoramularia* species, *N. spissa*, was also described on hosts of the family *Asteraceae*, but it clearly differs from *N. bidentis* in having solitary, 2-celled conidia, 6–9(–10) µm wide. Conidia of *N. bidentis* are catenate or solitary; they may be 1–3-celled and (2.5–) 3.5–5 µm wide (Braun 1998). The distribution of these species is also different: *Neoramularia spissa* is confined to North America (Canada, USA), while *N. bidentis* is known from Asia (Korea) and has currently been found in Europe (Poland).

In Poland, *Ramularia concomitans* Ellis & Holw. additionally occurs on *Bidens tripartita* (Ruszkiewicz 2000, Wołczańska 2005). The morphology of hila and conidiogenous loci, which are colorless and inconspicuous in *Neoramularia* and conspicuously darkened in *Ramularia*, is the main feature that differentiates the two genera.

The present collection of *N. bidentis* represents the first confirmed locality of this species in Poland and in Europe at all. The specimen collected by Danilkiewicz (1990) in Woroblin on the Bug River, published as *Ramularia concomitans*, probably also belongs to this species (Wołczańska 2005).

Recent Polish reports of newly found phytopathogenic fungi mostly concern taxa occurring either in plant communities barely researched by mycologists or in urban areas. Our specimens of *Neoramularia bidentis* on *Bidens tripartita* have also been recorded from habitats investigated less extensively (Ławrynowicz et al. 2004). Only a few fungal species are known on this host in Poland, namely *Leptosphaeria ogilviensis* (Berk. & Broome) Ces. & De Not., *Septoria bidentis* Sacc. (Mułenko & Majewski 2008), and a powdery mildew reported by different authors as *Sphaerotheca castagnei* Lév., *S. fuliginea* (Schltdl.) Pollacci, *S. fusca* (Fr.) Blumer emend. U. Braun as well as *S. xanthii* (Castagne) L. Junell (Sałata 1985, Mułenko 1989, Danilkiewicz 1990, Hołownia & Kostrzewska 1991, Kalinowska-Kucharska & Kadłubowska 1993, Dynowska et al. 1999, Czerniawska 2001). The herbarium material must be verified to confirm the taxonomic status of these specimens in *Podosphaera fusca* (Fr.) U. Braun & Shishkoff or *P. xanthii* (Castagne) U. Braun & Shishkoff according to the criteria proposed by Braun & Takamatsu (2000).

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Non-lichenized fungi from the Antarctic region

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Abstract — A reference checklist has been compiled giving the names of all species of non-lichenized fungi described by collection, observation or culture from the general Antarctic region since records were first published in 1847. The list gives the current names and taxonomic dispositions of over 1000 reported fungi (c. 750 species), together with links to bibliographic references for each report. Additional data include some details on the collection or isolation, and some limited information on associated organisms and substrates. The list is maintained online via the Antarctic Environmental Data Centre at: www.antarctica.ac.uk/bas_research/data/access/fungi/. The list is updated on a regular basis.

Key words — continental Antarctica, sub-Antarctic, maritime Antarctica, bibliography

Introduction

There is a long history of fungal recording from the Antarctic and sub-Antarctic areas dating from the mid part of the 19th century. In 1847 Berkeley described *Peziza kerguelensis* (= *Scutellinia kerguelensis*) as a new species from Christmas Harbour, Kerguelen from material collected by Hooker in 1840 (Berkeley 1847). Berkeley later reported further material from Kerguelen that had been collected during the HMS Challenger expedition of 1872–76 and by Eaton during the Transit of Venus expedition of 1874–75 (Berkeley 1877a,b). The first fungal material from the Antarctic mainland is generally accepted as *Sclerotium antarcticum* (= *Sclerotinia antarctica*) collected in 1898 from Danco Land on the Antarctic Peninsula during the expedition of SY Belgica (Bommer & Rousseau 1905, Gamundi & Spinedi 1987).

There have now been over 200 publications describing or reporting fungi from Antarctica since the early expeditions, and another 50–100 which are otherwise relevant to mycological study of the region. Pegler et al. (1980)

produced an annotated list of the macrofungi (*Ascomycota* and *Basidiomycota*) described from the region up to 1979, including 14 new species based on recently collected material. Some 90 species of largely filamentous microfungi from terrestrial sites were listed by Vishniac (1996). Onofri et al. (2007) reported 251 species of fungi and oomycetes from mainland continental Antarctica, but did not include details of species from the sub-Antarctic or many of the islands between the sub-Antarctic and the mainland. To date there has been no systematic listing of all of the 1000+ fungi reported from the region.

Methods and criteria

Scope and sources. For this list the Antarctic is defined (following Pegler et al. 1980) as the area south of 60°S, but also including Bouvet and the South Sandwich Islands. The sub-Antarctic is taken as being the area between 60°S and the Polar Front. The Polar Front is where warmer water from temperate regions meets cold water from the Antarctic and gives rise to an upwelling. The main information sources used were the libraries and herbaria of the British Antarctic Survey (AAS) and the Royal Botanic Gardens, Kew (K(M)). The main culture collections scanned were the American Type Culture Collection, the Centraalbureau voor Schimmelcultures, and CABI Europe. Other sources used included earlier unpublished literature searches and on-line resources including the GBIF database (via www.gbif.org).

Content and arrangement. Fungal data were recorded alphabetically in single tables in html files. Full citations for the appropriate references were included as an additional file. Each data entry was made up of the name of the fungus as reported, its higher taxonomic position (e.g. order), an indication as to whether the record was from the Antarctic or sub-Antarctic, its location, and (where clearly evident) the substrate or associated organism. The reference section provided details of at least one bibliographic reference that had reported the taxon in the region. Papers describing subsequent work with the collections outside the Antarctic region were not included to avoid duplication of reports, and fossil fungi known from the region (see Onofri et al. 2007) are also excluded. A small number of reviews were included, particularly where they also included new observations or combinations (e.g. Pegler et al. 1980). There are many additional publications relevant to the mycological study of Antarctica and a compilation of these now under preparation will be added to the web site in due course.

All taxa were initially listed under the names as reported. Species Fungorum (www.indexfungorum.org/Names/Names.asp.) and the CBS yeast taxonomic databases (www.cbs.knaw.nl/yeast/BioloMICS.aspx) were consulted to provide current names, order level placements and synonyms. Where these have been considered synonyms or there was a later re-determination, the original entry is limited to the name and original reference and hyperlinked to a full entry under the current name. In a few instances where a name could not be traced in the taxonomic literature or where there was some ambiguity in the original report, a full data entry was included with a brief explanation.

Data limitations. Searches on the species epithets '*antarctica*', '*antarcticus*' and '*antarcticum*' were generally not useful as these epithets have been used for collections from many southern hemisphere locations (e.g. Caretta & Piotelli 1977). The most difficult data sets to interpret were those on the source/substrate and the original location. In many instances sources were either not clearly specified, or given as 'soil' with no further details. The detail regarding location also varied considerably between reports, with some including specific location information and others limited to the name of an island or a region of the continent. In most cases this information is available in original or associated publications and databases, and these categories in the list currently largely contain minimum information that is gradually being improved at each update.

Lichen-forming fungi have not been included in the list. Antarctic species have been the subject of some contention (Dodge 1973, Castello & Nimis 1995, Hawksworth & Iturriaga 2006), but they have recently been comprehensively monographed by Øvstedal & Lewis Smith (2001, 2004) and a checklist has been published by Olech (2001). An online checklist of Antarctic lichens is also available at www.biologie.uni-hamburg.de/checklists/lichens/portalpages/portalpage_checklists_switch.htm. Lichenicolous fungi are included here as several reports and various names are not consistently listed in the above.

Access and use. The list is available at the Antarctic Environmental Data Centre, and can be accessed through the 'Data and Collections' page of the main BAS internet site at www.antarctica.ac.uk/bas_research/data/index.php, or directly at www.antarctica.ac.uk/bas_research/data/access/fungi/. The list comprises an initial front page linked to further pages providing background information and the data files. The list can be searched alphabetically or through a separate index of genera. The full list of references included can be obtained from the reference section of the supporting pages, or from the reference heading on each data page. The list is reviewed and updated periodically as data become available. The current version (2.3.1) is the sixth update since the first posting in 2005.

Results

Taxa included. Literature, herbarium and culture collection searches produced a list of 1034 different fungal or oomycete and myxomycete names from 416 genera including 215 species with alternative current names in Index Fungorum.

Of these, 884 had been identified at species level. All the major phyla within the kingdom *Fungi* were represented, with the *Ascomycota* and *Basidiomycota* the most frequent, accounting for 68% and 23% of the entries respectively. The remainder belonged to the *Zygomycota* (5%) and *Chytridiomycota* (3%), together with the non-fungal *Myxomycota* (1%) and *Oomycota* (1%). Some of the species names listed were ambiguous or considered synonyms in one or more reference source, and the final number of accepted species was estimated at between 730 and 750.

BIOGEOGRAPHY. Although the range and number of Antarctic fungal records is relatively limited, there are some trends that can be identified from the data. Larger fungi are mostly restricted to the sub-Antarctic and the islands. There are a few reports of larger fungi on the mainland but most of these are restricted to the Antarctic peninsular. At the current time the most southerly records for larger fungi are long established colonies of two moss-associated *Arrhenia/ Omphalina* spp. on Leonie Island (67° 34' S, 68° 08' W) currently under study. Fungal diversity in the Antarctic appears significantly reduced in relation to other regions. In very general terms individual niches appear to be occupied by only a few species, and the environmental factors defining the niche may be more significant than the geography.

ECOLOGY. The species that have been reported from the region include representatives of most functional/ecological groups. Potential plant and animal pathogens such as species of *Pythium, Fusarium, Trichophyton, Neozygites* and *Thyronectria* species are present, as are groups normally associated as mycorrhizae or plant or invertebrate symbionts. Relatively few species have been reported directly from associated hosts, but examples include *Octospora leucoloma* on moss covered soil, *Neozygites* sp. on mites, *Paecilomyces antarcticus* on springtails and *Pythium* sp. on liverworts (see checklist). In several instances species were not associated with their 'usual' function or niche in the Antarctic environment. Examples include the normally insect-associated species *Lecanicillium lecanii* that has been isolated from mosses and gypsum crusts on rocks, the ericoid mycorrhizal species *Rhizoscyphus ericae* that has been isolated from the roots of liverworts, and the normally coprophilous *Pirella circinans* that has been found closely associated with beetle cadavers on Bird Island (Hughes & Lawley 2003, Chambers et al. 1999, Bridge et al. 2008). The mainly tropical and subtropical wood-rotting bracket fungus *Pycnoporus coccineus* has been isolated from a mummified penguin. There have been comparatively few fungal isolations from the marine environment, but some of the more common genera identified from Antarctic sea water include *Aplanochytrium, Aniptodera, Camarosporium, Leucosporidium, Phoma* and *Thraustochytrium* (see checklist).

Discussion

The condition 'occurring in the Antarctic' is here considered to include fungi that are either clearly growing in the environment or are capable of surviving at least transiently as spores or other propagules. As a result, the list is almost entirely limited to recorded collections, observations or isolations. It does not include data on fungi recorded solely by molecular methods, where there were no other indications of their presence. Many of the fungal sequences obtained in molecular diversity studies (e.g. Lawley et al. 2004) will undoubtedly come from viable propagules or growing organisms, but interpretation and identification can be problematic (see Bidartondo et al. 2008) so such data are generally not included in the current version.

It is difficult to determine a precise level of endemism for Antarctic fungi. Pegler et al. (1980) commented that the macrofungus biota of the sub-Antarctic zone was remarkably similar to that of North Temperate-Arctic regions. Onofri et al. (2007) listed some 22 species of microfungi that they considered endemic to continental Antarctica, and a further 26 that are presumed able to grow there. Some studies have looked at the potential transport of propagules, including fungi, into the Antarctic in air movements. Chalmers et al. (1996) have shown that air movements could transport fungi from South America to the Antarctic, and that the meteorological conditions required would occur some three times in every two years (Chalmers et al. 1996, Marshall 1996). Airborne distribution would be less likely for many of the normally waterborne taxa such as *Pythium* spp. De Hoog et al. (2005) have demonstrated that some species of *Thelebolus* found in Antarctic lakes and deposits are also associated with birds, and such vectors may be involved in the routine introduction of fungi. Given the wide range of species reported in the region, and their generally cosmopolitan distribution, it would seem likely that less than 2–3% of Antarctic fungi are truly endemic, although some may occur in relatively long-established associations. This is similar to the lower plants present where many have wide or bi-polar distributions (Bednarek-Ochyra et al. 2000).

Acknowledgments

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Villosiclava virens gen. nov., comb. nov., teleomorph of *Ustilaginoidea virens*, the causal agent of rice false smut

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Abstract—False smut is a serious worldwide rice disease. The anamorphic state of the causal fungus is *Ustilaginoidea virens*. The teleomorphic state was introduced in 1934 and was allied with the family *Clavicipitaceae*. At present *Claviceps virens* is applied as the teleomorph name of this fungus. However, morphological and biological characteristics of the teleomorph are distinct from those of the genus *Claviceps*. In particular, the *Ustilaginoidea* anamorph differs from the *Sphacelia* anamorph that characterises the genus *Claviceps*. We deliberated on the nomenclature of rice false smut fungus, compared the fungus with *Claviceps*, and found it is not appropriate to any existing clavicipitaceous genera. In this paper, a new genus *Villosiclava*, a new combination *V. virens* and an emended description for the teleomorph of rice false smut fungus are proposed. In the absence of the original specimen, an epitype is also designated.

Key words—anamorph-teleomorph connection, *Ascomycota*, *Hypocreales*, mycotoxin, taxonomy

Introduction

False smut is a serious disease in rice cultivation areas throughout the world. The false smut disease affects the grains within the panicles and reduces rice yield and quality (Ono & Uehara 1949). It has not attracted as much attention as rice blast disease, partly because false smut and rice blast occur under similar conditions in Japan (Yaegashi et al. 1989). In addition to affecting rice production, water extracts of false smut diseased grains have been reported to poison animals (Nakamura et al. 1992, Suwa 1915). Furthermore, diseased spikelets contaminate the rice harvest (Sonoda 1996).

The causal agent fungus forms so-called 'green balls' in place of a rice fruit. Such balls are round or oblong in shape and uneven on their surface. The pseudoscrelotia (green balls) consist of mycelial tissue and spore-masses and incorporate remnants of anthers and portions of paleae and lemmas (Ikegami 1961). The spore masses are of orange to olive green colour, powdery and somewhat sticky. The anamorph name of the causal fungus is *Ustilaginoidea virens*.

The teleomorph name of this fungus is currently *Claviceps virens*. However, phylogenetic analyses have demonstrated that *Ustilaginoideae* species were not allied with the genus *Claviceps* (Bischoff et al. 2004, Tanaka & Tanaka 2008, White et al. 2000). Therefore, a taxonomic study on the teleomorph stage of this fungus was performed and a new holomorphic name is here proposed.

Materials and methods

The ascigerous stage of rice false smut fungus was produced following previously reported methods (Sakurai 1934, Hashioka et al. 1951) with slight modification. True sclerotia were collected from rice spikelets on 8 October 2007 at Joetsu, Niigata Prefecture, Japan (37° 15' 38 "N, 138° 28' 58"E) by T. Ashizawa. The true sclerotia were laid on moistened quartz-sand in glass petri dishes, maintained at 4°C for 1 month, and then placed at 24–28°C under fluorescent light and dark conditions. Examined specimens were deposited in the mycological herbaria of the National Museum of Nature and Science, Tokyo, Japan (TNS), and the Natural History Museum and Institute, Chiba, Japan (CBM).

Vertical and longitudinal sections of mature capitula were obtained using a paraffin embedding technique. Briefly, the fruiting bodies were fixed in FAA solution [4% (v/v) formaldehyde, 5% (v/v) glacial acetic acid, and 50% (v/v) ethanol], dehydrated, embedded in paraffin and sectioned at a 10 μm thickness. Microscopic characteristics were observed by differential interference contrast microscopy.

Results and discussion

The ascigerous stage on the true sclerotia emerged during March to May 2008. The characteristics of the fruiting bodies, ascostromata, perithecia, and asci coincided with the descriptions of Sakurai (1934) and Hashioka (1971). The true sclerotia generally had 1–5 stipitate, capitate fruiting bodies (Fig. 1A, B, C). The fruiting bodies were initially bright yellow and then changed to dark green. The stipes were shaggy and 5–15 mm in height (Fig. 1B, C, D). The ascostromata were 1–3 mm in diameter. Perithecia were subcortical, and ovate to pyriform

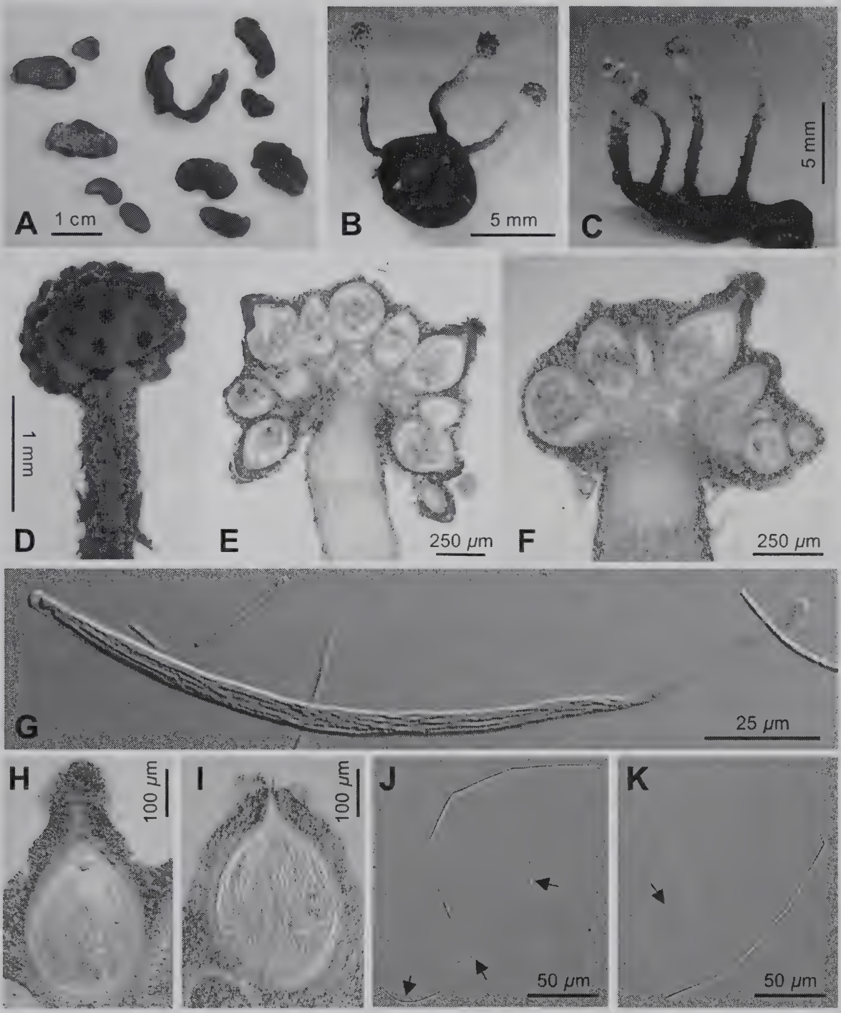


Fig. 1. Teleomorph of *Ustilaginoidea virens* (TNS-F-18423). A: true sclerotia of various shapes; B, C: stipitate, capitate ascostroma emerging from true sclerotia; D: ascostromata with shaggy stipe; E, F: longitudinal sections of ascostromata; G: ascus with thickened apex; H, I: longitudinal sections of perithecia ejecting ascospores through the ostiole; J, K: ascospores disarticulating into 4 part-spores and individual part-spores (arrows).

(Fig. 1E, F, H, I). Asci were numerous in a perithecium, hyaline, cylindrical, with hemispherical and thickened apex, base attenuated and 8-spored (Fig. 1G, H, I). Ascospores were 140–230 µm and disarticulated into 4 part-spores which were hyaline, one-celled, filiform and 30–60 µm × 1.3–1.8 µm (ave. 45 × 1.5 µm; Fig. 1J, K). Previous descriptions reported ascospores to be 120–180

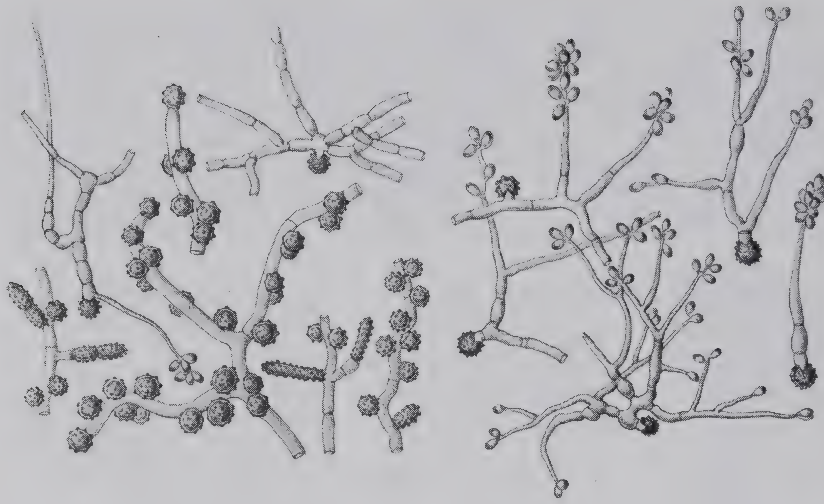


Fig. 2. *Ustilaginoidea* by Brefeld (1895), illustrated when the genus name *Ustilaginoidea* was described. Pleurogenous thick-walled conidiospores and germination of thick-walled spores with the formation of secondary conidiospores are shown.

µm × 0.5–1.0 µm (Sakurai 1934) or they were hyaline, one-celled, filiform and 50–80 µm × 0.5–1.5 µm (Hashioka 1971). These descriptions suggest that part-spores were mistaken for ascospores. Thus, emendation of the description for this fungus has been provided.

History of the rice false smut fungus

The anamorphic name of the rice false smut fungus is *Ustilaginoidea virens*. Cooke (1878) first named the rice false smut fungus *Ustilago virens*, based on 'a rice smut' collected in India. Patouillard (1887) independently named the fungus *Tilletia oryzae*, based on specimens collected in Japan. Brefeld (1895) proved that *Tilletia oryzae* belonged to the fungi imperfecti, and not to the basidiomycete family *Ustilagineae*. Brefeld (1895) proposed a new anamorphic genus *Ustilaginoidea* (Fig. 2) based on the characteristics of the conidial stage on rice and on *Setaria crus-ardeae*, and named the two species *U. oryzae* and *U. setariae*, respectively. Takahashi (1896) pointed out that *Ustilaginoidea oryzae* was identical with *Ustilago virens*, and thus combined the scientific name as *Ustilaginoidea virens*, which was based on priority of epithet.

The teleomorph of the rice false smut fungus had not been found for almost 40 years. Brefeld (1895) supposed that the rice false smut fungus was an anamorphic state of *Ascomycetes*. Subsequently, Brefeld (1896) found an ascigerous stage of *U. setariae*. He described, without illustrations, the development of the fruiting bodies on true sclerotia and the fructification of asci and ascospores. Brefeld (1896) also stated that the anamorphic genus *Ustilaginoidea* was associated with *Hypocreales.* However, he did not propose a new taxonomic name based on the teleomorph. Sakurai (1934) first found the ascigerous stage of rice false smut fungus on true sclerotia. The true sclerotia, which were hard, black and somewhat flattened, protruded from false smut balls on rice. To date, the teleomorph of rice smut fungus has been reported in Japan (Sakurai 1934, Hashioka et al. 1951), Korea (In et al. 1984), India (Singh & Dubey 1984) and China (Wang et al. 1998). On the true sclerotia, stipitate and capitate ascostromata develop (Sakurai 1934). Numerous perithecia were embedded in the head of the fruiting body (Hashioka 1971). Sakurai (1934) suggested that the rice false smut fungus was similar to *Claviceps* Tul. (*Clavicipitaceae*), but did not propose a scientific name for the teleomorph.

Legitimacy of the current name of the rice false smut fungus

Claviceps oryzae-sativae (Hashioka 1971) has been often used as the teleomorphic name of this rice false smut fungus (e.g. Bischoff et al. 2004, Singh & Dubey 1984). However, Nakata (1934) already classified the fungus as "*Claviceps virens* (Cke.) Sakurai" and provided a set of illustrations of the teleomorph. While Nakata (1934) proposed the nomenclature only in Japanese, the name fulfilled the requirements for valid publication at that time (McNeill et al. 2006: ICBN Art. 36.1). This name is regarded as a formal error, because the teleomorph is a new morph of the false smut fungus and such a morph should be described as a new species (ICBN Art. 59.6). Therefore, this name is attributed solely to Nakata (1934) and should be treated as *Claviceps virens* M. Sakurai ex Nakata (ICBN Art. 46.4).

We recognized that the publication by Nakata (1934) was valid and that *Claviceps virens* was the existing holomorphic name of the rice false smut fungus being advocated. Nevertheless, Hashioka (1971) designated the teleomorph of this fungus as *Claviceps oryzae-sativae* as an avowed substitute (nomen novum), and treated the former *Claviceps virens* as a naked name (nomen nudum). Hashioka (1971) did not indicate any reason for this treatment. We suspect that he may have misapplied ICBN Art. 35.1 or misinterpreted Art. 36.1 when reviewing the publication by Nakata (1934). Alternatively, he may have considered that *Claviceps virens* (Nakata 1934) was a provisional name and was invalidly published (ICBN Art. 34), because Nakata (1937) in his second and later editions of the same illustrated book classified the fungus as *Ustilaginoidea virens*. However, because Nakata (1934) did not explicitly suggest that *Claviceps virens* was a provisional name, it is not invalidated by ICBN Art. 34. In addition, Hashioka (1971) did not designate a type, probably because "a new name published as an avowed substitute for an older name is typified by the type of the older name" (ICBN Art. 7.3). Therefore, the name *Claviceps oryzae-sativae* should be typified by the type of *Claviceps virens*. Thus the name *Claviceps oryzae-sativae* is superfluous and therefore illegitimate (ICBN Art. 52.1).

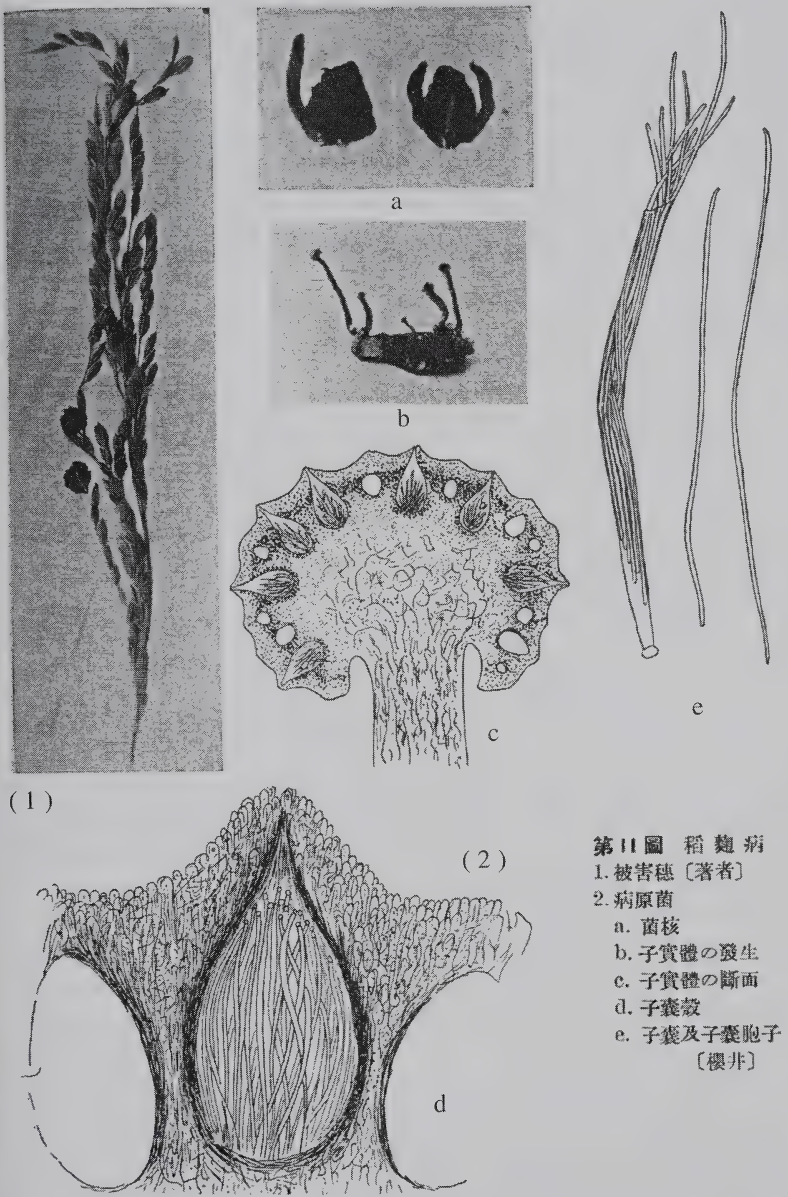
The holotype was a set of illustrations drawn by M. Sakurai (FIG. 3) in the publication by Nakata (1934). Unfortunately, the holotype illustration cannot be critically identified for use in the precise application of the name of a taxon (ICBN Art. 9.7). Thus, it is necessary to designate an epitype specimen in support of the holotype.

Ahuja & Payak (1988) remarked that the false smut fungus should be named *Ustilaginoidea virens*, not *Claviceps oryzae-sativae*. However, it was inappropriate to apply the name *Ustilaginoidea* to a teleomorphic species at that time, because the description of the genus *Ustilaginoidea* did not include a teleomorph (Brefeld 1895). As a result, the genus *Ustilaginoidea* was applicable only to the anamorph (ICBN Art. 59.3).

Taxonomic study

The rice false smut fungus differs from *Claviceps purpurea*, the type species of the genus *Claviceps*, in several respects. The conidial state of most *Claviceps* species is *Sphacelia* Lév., which is characterised by sporodochia with hard hypostroma and honeydew-like exudates. The conidia are typically hyaline, thin-walled and single-celled. The sclerotia of *Claviceps*, which give rise to ascostromata, are irregularly globose, subglobose or elongated ovoid to cylindrical in shape (Langdon 1954). In contrast, the rice false smut fungus conidial state is *Ustilaginoidea*, which forms pleurogenous, sessile, pulverulent, dark-coloured verrucose thick-walled conidiospores, and hyaline spherical secondary conidiospores. The sclerotia are somewhat flat and irregular oblong or horseshoe-shaped. In the *Clavicipitaceae*, teleomorph-anamorph connections were thought important to their taxonomy (Diehl 1950), and that suggestion was recently supported by molecular phylogeny (Kuldau et al. 1997, Sung et al. 2007). Further molecular phylogenetic analyses have demonstrated that *Ustilaginoidea* species are distinct from *Claviceps* (Bischoff et al. 2004, Tanaka & Tanaka 2008, White et al. 2000). In addition, *Claviceps* species invade host plants at the flowering stage, while the rice false smut fungus invades rice plant at the booting stage or earlier (Fujita et al. 1989, Hisada 1936, Ikegami 1961). *Claviceps* species accumulate ergot alkaloids in the sclerotia; whereas, the false smut fungus does not produce ergot alkaloids (Yamashita 1965) but produces several cyclic peptides, i.e., ustiloxins A–F, which were isolated from water extracts of false smut balls (Koiso et al. 1992, 1994, 1998; Li et al. 1995).

In the genus *Claviceps*, some poorly known species, such as *C. flavella* (Berk. & M.A. Curtis) Petch, *C. diadema* (Möller) Diehl and *C. orthocladae* (Henn.) Diehl, produce pseudosclerotia in grains (Pazoutova 2003, Diehl 1950). The


a
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第11圖　稻麴病
1. 被害穗〔著者〕
2. 病原菌
a. 菌核
b. 子實體の發生
c. 子實體の斷面
d. 子囊殼
e. 子囊及子囊胞子
〔櫻井〕

Fig. 3. Illustration of teleomorph of rice false smut fungus by Sakurai as presented in Nakata (1934) with permission from the publisher. Rice false smut disease; 1: diseased inflorescence (by Nakata). 2: causal fungus (by Sakurai). a: sclerotia; b: fruiting bodies; c: longitudinal section of ascostroma; d: perithecia; e: ascus and ascospores (original legend in Japanese).

mass of conidia in the host spikelet resembles the false smut ball of *U. virens*. Further, *C. orthocladae* has yellow and villous stipitate ascostromata. However, all these species have sphacelial anamorphs. Therefore, they are not congeneric with the teleomorph of *U. virens*.

Thus, there exists numerous morphological, phylogenetic, ecological and physiological differences between *Claviceps* and the teleomorph of *U. virens*. There are no available genera possessing characteristics of the *Ustilaginoidea* anamorph. For these reasons, we propose a new genus in the *Clavicipitaceae* to accommodate holomorph of the rice false smut fungus.

Genus description

Villosiclava E. Tanaka & C. Tanaka, **gen. nov.**
MycoBank MB512265

SCLEROTIA *applanata, inaequaliter oblonga.* ASCOMATA *capitata, stipitata, erecta e sclerotio.* STIPITES *cylindrici, villosi.* PERITHECIA *ovato-pyriformia, partim vel omnino in stromate immersa.* ASCI *apice hemisphaerico et inspissato, cylindrici, hyalini, 8-spori.* ASCOSPORAE *filiformes, hyalinae.* ANAMORPHE Ustilaginoidea.

SPECIES TYPICA: *Villosiclava virens* (Nakata) E. Tanaka & C. Tanaka

ETYMOLOGY: Latin, villosus, shaggy and clava, club; referring to *Claviceps*-like clavate fruiting body with shaggy stipe.

SCLEROTIA flattened, irregular oblong. ASCOMATA stipitate and capitate arising from sclerotia. STIPES cylindrical and villose. PERITHECIA ovate-pyriform, subcortical in ascomata. ASCI cylindrical, hyaline, 8-spored, hemispherical at the apex. ASCOSPORES filiform, hyaline. ANAMORPH *Ustilaginoidea* Bref. The type species is *Villosiclava virens*.

COMMENTS—The anamorphic state, *Ustilaginoidea,* is characterised by pleurogenous pulverulent smut-like conidia occupying ovaries of *Gramineae.* Primary conidia are globose to subglobose, yellow to dark-coloured and verrucose. Secondary conidia are globose to ellipsoid, hyaline and smooth.

New combination and emended species description

Villosiclava virens (Nakata) E. Tanaka & C. Tanaka, **comb. nov. et emend.** (FIG. 1)
MycoBank MB512266

Basionym: *Claviceps virens* M. Sakurai ex Nakata, Illustrations of Crop Diseases, 1st Ed. 18 (1934)
≡ *Claviceps oryzae-sativae* Hashioka, Riso 20(3): 238 (1971) (nom. illegit.)

Anamorph: *Ustilaginoidea virens* (Cooke) Takah., Bot. Mag., Tokyo 10: 19 (1896)
≡ *Ustilago virens* Cooke, Grevillea 7: 15 (1878)
≡ *Sphacelotheca virens* (Cooke) Omori, Bot. Mag., Tokyo 10: 31 (1896)
= *Tilletia oryzae* Pat., Bull. Soc. Mycol. France 3: 119 (1887)
≡ *Ustilaginoidea oryzae* (Pat.) Bref., Unters. Gesammtgeb. Mykol. 12: 194–195 (1895)
= *Ustilaginoidea albicans* Shu Wang & J.K. Bai, Mycosystema 16: 257 (1997)

Species description by Nakata (1934) is emended as follows.

Sclerotia flat, botuliform, reniform, horseshoe-shaped, or differently shaped, 1 to several, usually 2, protruding from pseudosclerotia (false smut balls) on spikelet of rice, usually 5–13 mm long, 2–5 mm wide, 1–2 mm thick. Ascomata stipitate and capitate, 1–9 arising from the sclerotia. Stipes 5–15 mm long, cylindrical, shaggy, phototropic, initially yellow then becoming dark-coloured. Capitula globose, 1–3 mm in diameter, papillate when mature. Perithecia ovate to pyriform, 150–350 µm long, 70–150 µm wide, embedded in the surface of capitula, ostioles evidently erumpent. Asci cylindrical, hyaline, 130–300 µm long, 4–7 µm wide with thickened apical cap. Ascospores filiform, hyaline, eight per ascus, septate, 140–230 µm long, 1.3–1.8 µm wide, disarticulating at septa to form 4 part-spores. Part-spores aseptate, 30–60 µm long. Anamorph, *Ustilaginoidea virens.*

Specimens examined: TNS-F-18423—***epitypus hic designatus***, CBM-FA-37300, originated from true sclerotia on grains of *Oryza sativa*, Joetsu-shi, Niigata, Japan. Ex-epitype cultures originated from individual ascospores were deposited as MAFF 240994 and MAFF 240995 at the culture collections Genebank, National Institute of Agrobiological Sciences, Tsukuba, Ibaraki, Japan.

The holotype supported by this epitypification is the illustration by Sakurai in Nakata (1934) (q.v. Fig. 3). The original description in Japanese was published in Nakata (1934). A Latin description was published in Hashioka (1971).

Comments—At present, there is a single species in this genus. The teleomorph of *U. setariae* is probably congeneric with *V. virens*, because it had true sclerotia, yellow stipitate capitate ascostroma and ascospores disarticulating into 4 part-spores (Brefeld 1896). Further studies are needed to obtain a conclusion. Other fungi possessing the *Ustilaginoidea* anamorph may be included in this genus, when an ascigerous stage is observed.

White mutants of rice false smut fungus have been occasionally reported in Japan (Yaegashi et al. 1989, Honkura et al. 1991). *Ustilaginoidea albicans*, reported from China (Wang & Bai 1997), is apparently a white mutant of the rice false smut fungus. Both of these were characterised by their white colour and the less verrucose surface of their spores (Honkura et al. 1991, Wang & Bai 1997).

The anamorphic genera *Munkia* Speg. and *Neomunkia* Petr. are morphologically and phylogenetically close to *Ustilaginoidea* (Bischoff et al. 2004). Bischoff et al. (2004) suggested that the teleomorphic genus *Mycomalus* Möller may be linked to *Munkia martyris. Mycomalus*, however, has no true sclerotia and lacks stipitate ascostromata, but exhibits globose ascostromata on bamboo stem, and their ascospores disarticulate into fusoid part-spores (Möller 1901). These characteristics are different from the teleomorph of *U. virens.*

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Validation of the basidiomycetous yeast species *Cryptococcus flavus* and *C. liquefaciens*

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Abstract — Novel combinations are proposed to validate the binomials of two currently accepted species belonging to the basidiomycetous yeast genus, *Cryptococcus.*

Key words — *Basidiomycota,* nomenclatural change

Introduction

When Phaff & Fell (1970) transferred *Rhodotorula flava* to the genus *Cryptococcus* Vuill. as *C. flavus*, they failed to cite the basionym, *Torula flava.* This omission rendered the new combination invalid (ICBN Art. 33.4; McNeil et al. 2006). Nonetheless, the name was accepted in subsequent yeast taxonomy treatises (e.g., Fell & Statzell-Tallman 1998, Rodrigues de Miranda 1984) and was confirmed as a separate species by several molecular phylogenetic studies (e.g., Fell et al. 2000, Scorzetti et al. 2002, Takashima & Nakase 1999).

Fonseca et al. (2000) transferred *Torulopsis liquefaciens* to the genus *Cryptococcus* as *C. liquefaciens*, but an incorrect citation of the basionym rendered the new combination invalid (ICBN Art. 33.4, Note 1). *Cryptococcus liquefaciens* was confirmed as a separate species by subsequent molecular phylogenetic studies (Scorzetti et al. 2002, Sugita et al. 2003). We hereby propose two novel combinations to validate the binomials *Cryptococcus flavus* and *C. liquefaciens.*

Nomenclatural changes

Cryptococcus flavus (Saito) Á. Fonseca, Boekhout & Fell, **comb. nov.**
MycoBank 512451
Basionym: *Torula flava* Saito, Japanese J. Botany 1(1): 45 (1922).
≡ *Chromotorula flava* (Saito) F.C. Harrison (1928).
≡ *Rhodotorula flava* (Saito) Lodder (1934).
≡ *Rhodotorula tokyoensis* var. *flava* (Saito) T. Haseg. (1958).
= *"Cryptococcus flavus"* (Saito) Phaff & Fell (1970), nom. inval. (Art. 33.4).

Cryptococcus liquefaciens (Saito & M. Ota) Á. Fonseca, Boekhout & Fell, **comb. nov.**
MycoBank 512452
Basionym: *Torulopsis liquefaciens* Saito & M. Ota, J. Brewery Science (Japan) 12: 167 (1934).
= *"Cryptococcus liquefaciens"* (Saito & M. Oda) Á. Fonseca, Scorzetti & Fell (2000), nom. inval. (Art. 33.4).

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p.153, line 22	for: *micholsonii*	read: *nicholsonii*
p.509, col. 1	*for:* Boubovia micholsonii	read: *Boubovia nicholsonii*

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front cover, legend	*for:* Heterochaete *tenuicula* sp. nov.	*read: Heterochaete tenuicula* (Lév.) Pat.
p.iii, line 1	*for:* VOLUME ONE HUNDRED FIVE	*read:* VOLUME ONE HUNDRED FOUR
p.194, lines 18–19	for: *Exsiccata 357*, holotype; *BPI 845215* & *BPI 786230*, isotype	
	read: *Exsiccata 357 — BPI 845215* & *BPI 786230*, syntypes	
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p.489, line 6	for: *Arthonia hawksworthii* Halici, p. 94	
	read: *Arthonia hawksworthii* Halici, p. 90	
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p. 494, 3rd line up	*for:* Takimichi Orihara	*read:* Takamichi Orihara
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